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GEOLOGY OF THE BEACONSFIELD DISTRICT, INCLUDING THE ANDERSON'S CREEK ULTRABASIC COMPLEX

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ABSTRACT

Precambrian quartzites and phyllites are unconformably overlain by eugeosynclinal sediments of the Cambrian System. In the western part of the area the Cambrian sediments were intruded during the Upper Cambrian by ultrabasic and basic rocks of the Anderson's Creek Complex. The main rock type is partially or completely serpentinized enstatolite with lesser peridotite and clinopyroxene-rich rocks. Pyroxene gabbro with lesser hornblende gabbro occurs as a western and northern marginal belt of small intrusions and as pegmatitic phases within the complex. The pyroxene gabbros show partial or complete alteration to rodingites. Small albitite bodies occur within the complex.

During the Ordovician Period the miogeosynclinal Junee Group was deposited conformably in the east and unconformably in the west on the Cambrian rocks. The Junee Group shows rapid facies and thickness variation and is probably matched to the east by 5,000′ of "Mathinna Group" sediments. Post-Ordovician orogenic movements (Tabberabberan Orogeny) with the maximum stress directed to the W.S.W. resulted in asymmetrical folding, steep thrusting and transcurrent faulting of the Junee Group and also caused diapiric cold movement of the ultrabasic complex.

During the Permian Period about 1,700′ of marine sediments with strong glacial influence were deposited on a slightly irregular pre-Permian surface. A short fresh-water phase occurred near the middle of the sequence and at the top of the marine sequence there is an abrupt change into the fresh-water Clog Tom Sandstone overlain by the Triassic fresh-water beds.

Several discordant intrusions of dolerite were emplaced during the Jurassic Period and the major intrusion was controlled by the Palaeozoic structural trends. During the early Tertiary Period tensional faulting was followed by lacustrine sedimentation and then by minor extrusion of olivine basalt. A late Tertiary sea level at about 300′ above the present level caused deposition of blanket-like vein-quartz gravels. More recent lower sea levels have allowed removal of Tertiary sediments from much of the area.

INTRODUCTION

This report summarizes the results of the geological mapping of the area between 469,000E-480,000E and 920,000N-930,000N (plate 1, fig. 1), surrounding the township of Beaconsfield in Northern Tasmania. The work was carried out during 1956 as part of a B.Sc. (Hons.) course at the University of Tasmania.

Earlier publications on the area include a number of reports on local parts of the area, particularly on the former chrysotile quarries at Anderson's Creek and the gold mines at Beaconsfield. During the latter part of 1956 and early 1957, Dr. G. Baker of the C.S.I.R.O. made an independent study of some of the rocks from the Anderson's Creek Ultrabasic Complex.

ACKNOWLEDGMENTS

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TOPOGRAPHY

The area under discussion lies between the 2,000′ Asbestos Range, composed of Precambrian quartzites and schists, to the west and the Tamar Estuary with its shores of Tertiary, Mesozoic and Permian rocks to the east. Between these two the folded and faulted Lower Palaeozoic sediments and igneous rocks give rise to a number of prominent linear ridges.

The Cabbage Tree Conglomerate characteristically forms resistant, comparatively high ridges, including Blue Tier and Cabbage Tree Hill (650-200 feet), Blue Peaked Hill (950 feet), and the ridges on the eastern margin of the ultrabasic complex. The Blue Tier-Cabbage Tree Hill ridge is cut by streams in only two places and both of these are along fault lines. The remainder of the Cambrian, Ordovician, Permian, Triassic and Tertiary sediments generally form low, gently undulating country. However, the keratophyre member of the Dally's Siltstone, the Jurassic dolerite and the Permian Liffey Sandstone, tend to be more resistant to erosion and form low scarps or more prominent hills.

Anderson's Creek, the major stream in the area, flows through a rather mature valley in the ultrabasic rocks but has two small gorges giving rise to local base levels. These gorges occur north of Settlers Hills and north-west of Simmonds Hill. In the lower part of its course Anderson's Creek is flowing to a large extent on Permian bedrock.

The central north part of the area is an undulating surface, quite constant in height (200-230 feet) at its southern edge but descending to 100-120 feet to the north. A similar surface extends south-west towards Anderson's Creek and rises in this direction to 400-430 feet. The latter part of the surface has more relief than the northern part but is similarly covered with stunted vegetation growing on vein-quartz gravels. These blanket-like deposits of gravel extend over the Owen Conglomerate forming the eastern margin of the ultrabasic complex, and rest directly on the complex itself. In this area the gravels tend to be more resistant to erosion than the underlying serpentinite with the result that this side of the Anderson's Creek valley is a small escarpment with many old landslip scars.

Recent Changes in Sea-Level as Recorded by Shorelines and River Terraces:—Except at stream mouths the shores of Middle Arm are characterized by rather wide shore platforms in front of a cliffed shore. A 10-15 feet level can generally be observed either as a cliff-top level or as a terrace with its base some 3-5 feet above the present shore platform. This 10-15 feet level is also well developed on the shores of West Arm near the mouth of Anderson's Creek.

In some places, particularly north of Swift's Jetty, there is a distinct bench at 25-30 feet and this in some places rises directly from the shore platform. Benches have also been observed at 70-80 feet in several places but these are isolated cases and their significance and former extent is unknown.

The lower two benches are erosional surfaces cut in the Permian and Triassic sediments and seem most reasonably regarded as old shore lines.

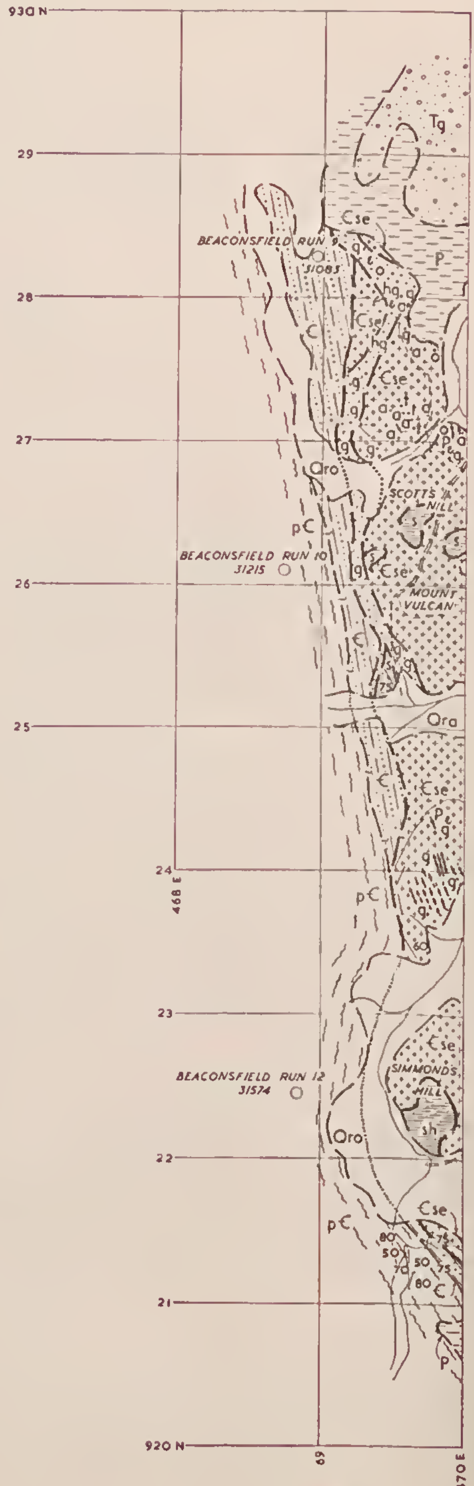

FIGURE 1

South of Settlers Hills there are no terrace levels evident on Anderson's Creek. However, at Leonardsburgh there is a distinct terrace 20-25 feet above creek level—this terrace is cut in Permian sediments and capped by river conglomerate. Further north there are two terrace levels present, one ten feet and the other about 30 feet above creek level. The 10 feet level is continuous with the 10-15 feet level on the shore of West Arm and the 30 feet level is probably related to the similar level on the shores of Middle Arm.

East of the West Tamar Highway, Blyth's Creek is also entrenched about 10 feet in a flat composed of alluvium and of Permian or Tertiary sediments. There is also some evidence of a higher terrace level.

The evidence from both stream terraces and old shore-lines points to two comparatively recent falls in sea-level, the later one of about 10-15 feet and the earlier of a further 10-15 feet or more.

STRATIGRAPHY

Precambrian Rocks.

Precambrian rocks occur only on the western margin of the area mapped and no attempt was made to examine them in detail. These Precambrian rocks consist of thick-bedded quartzites and quartz-sericite phyllites both possessing a clearly defined schistosity and lineation.

The age of the Simmonds Hill Metamorphics and the Settlers Metamorphosed Greywacke is either Cambrian or Precambrian.

Cambrian System.

The contact between Cambrian and Precambrian rocks cannot be observed in the field. Near 697E 214N there is only a 20-yard gap between Cambrian and Precambrian outcrops. The former dips northeast at a steep angle and does not show any small-scale folding. The Precambrian here, and slightly to the west, shows small-scale folding with rapid variation of dips. Structural unconformity is established in this area and stratigraphic unconformity is inferred. For a distance of about three miles north from 695E 240N the contact between Cambrian and Precambrian is obscured by scree of more resistant Precambrian. The contact zone runs as a fairly well defined linear and it is probably a simple unconformity, dipping steeply north of east. However, the possibility of a major fault cannot be ruled out.

Cambrian sediments occur in four separate areas and structural environments. Correlation between these areas was found to be impossible and in two areas only was exposure sufficiently good to enable definition of several formations and members.

Dally's Siltstone.

The Dally's Siltstone is defined as that formation dominantly of greywacke and subgreywacke siltstones lying conformably below the Junee Group east of Blue Tier. It is Middle to Upper Cambrian in age and the typical exposures occur at 765E 236N, about 400 yds. east of Dally's Quarry from which the formation takes its name.

The Dally's Siltstone is not less than 1,100 feet and probably over 2,000 feet thick. The base of the formation is not exposed. The formation contains interbedded black and brown slates with occasional fine greywacke conglomerates and some siltstones. These are overlain by dull brown, subgreywacke siltstones and then by impure quartz sandstones. These sandstones seem to lie on approximately the same horizon as a keratophyre lens, located to the south. The keratophyre will be discussed in the section on igneous petrology but is overlain near 779E 217N by hard, fossiliferous subgreywacke sandstone, then by micaceous phyllites and finally by fossiliferous yellow-brown subgreywacke siltstones. This is overlain by the Blyth's Creek Formation of the Junee Group. There is no evidence of an unconformity between the Dally's Siltstones and the Junee Group, but a disconformity may or may not be present.

Poorly preserved brachiopods and trilobites were found only in the upper part of the formation. The following is an extract from a letter from Dr. A. A. Opik to Mr. M. R. Banks concerning these fossils: "I myself am inclined to interpret this cranidium as belonging to *Dresbachia* or a related genus that occurs in this same O'Hara Shale at its base. The third possibility is *Bolaspidella*, a genus of the Middle Cambrian-Upper Cambrian passage in America. A genus related to *Dresbachia* occurs also in Tasmania in the Comet Slate in association with *Blackwelderia biloba*, and another form in the Upper Cambrian of the Ring River. All this indicates only one age for the Beaconsfield fauna—top of the Middle Cambrian and/or lowermost Upper Cambrian".

Ilfracombe Slate.

The Ilfracombe Slate is that formation of black slate and greywacke lying conformably below the Junee Group and outcropping immediately west of Cabbage Tree Hill and Blue Tier. Typical exposures occur near 735E 256N. The formation occupies a similar stratigraphic position to and probably interfingers with the Dally's Siltstone.

The upper 1,000 feet or so of the formation consist of black slate and fine greywacke siltstone. The lower 600 feet contain more abundant greywacke sandstone and siltstone and also subgreywacke and quartzose sediments. Scott (1952) described a thin section of picrite basalt from the "Western Tasmania Copper Mine at Beaconsfield". This was probably from the Ilfracombe Slate but its presence could not be confirmed by the author's field work. No fossils were found so that the formation is placed in the Cambrian System on lithology and stratigraphic position only.

Undifferentiated Cambrian Sediments.—Surface float of impure quartzites and greywacke siltstone occurs on a hill at 729E 204N. The lithology is suggestive of Cambrian sediments and this is consistent with their structural position at the core of a major anticline.

Along the greater part of the western edge of the Anderson's Creek Ultrabasic Complex there is a narrow strip of Cambrian sediments between the Complex and the Precambrian rocks of the Asbestos Range. In only two areas (698E 214N and 691E 270N) is there any solid outcrop of these sediments but surface float is not uncommon along the whole belt. The thickness of sediments cannot be gauged accurately but near 698E 214N there is probably no more than 250 feet of thin black slate, impure sandstones, including greywackes, and possibly some tuffaceous material. Near the contact are quartz-albite-amphibole rocks probably formed by metamorphism of the sediments by the Complex. The following rock-types were seen, generally as surface float, in this belt of sediments:—Clay-pellet sub-greywackes; siltstones, some possibly tuffaceous; black and brown slates; reddish quartz sandstones with much clayey matrix and large muscovite flakes; dark-grey greywackes or tuffs. No fossils were found in any of these rocks and correlation with the Cambrian System is purely on lithological and structural grounds.

Ordovician System

The Junee Group.—The Ordovician sediments of the Beaconsfield Area can now be correlated with the Junee Group of other parts of Tasmania. The names Beaconsfield Series and Cabbage Tree Hill Series have previously been applied to rocks now correlated with the Junee Group, but these names have been discarded in favour of the established Junee Group since the previous terms have not been formally defined and appear to include rocks now regarded as Cambrian.

The Relationship between the Junee Group and the Cambrian System.—The Junee Group occurs in four different structures in the area and its relationship to the underlying Cambrian System must be discussed separately for each of these areas.

The most easterly belt of the Junee Group overlies the Dally's Siltstone near 782E 214N and 767E 240N. In this area the Junee Group in the northern outcrops shows minor folding and, although outcrop is not sufficiently good to confirm the relationship, the basal Blyth's Creek Formation is considered to overlie conformably the Dally's Siltstone.

The Junee Group on Cabbage Tree Hill and Blue Tier probably rests conformably on the Ilfracombe Slate. Although the contact cannot be seen and surface mapping does little to solve this problem, there is no evidence of unconformity. A number of the cross cuts and shafts of the Tasmania Gold Mine passed from the Junee Group into the Ilfracombe Slate. The sections through Cabbage Tree Hill given by Montgomery (1891), Twelvetrees (1903), and Hughes (1953) all agree in showing the grits and conglomerates of the Junee Group underlain conformably by slates of the Cambrian System. The relationship between the Cambrian sediments near 730E 205N and the Cabbage Tree Conglomerate to the north-east is completely unknown due to lack of outcrop.

The westernmost exposures of the Junee Group in the area rest directly on the Anderson's Creek Ultrabasic Complex and unconformity is clearly established. The contact is not exposed but an impure sandstone from very near the base of the sediments occurs on the old roadway at 7108E 2633N. A thin section (No. 8182) of this sediment shows that it consists of 60-70% of large, irregular, fibrous grains of tremolite-actinolite set in a matrix of fine-grained, sub-rounded quartz and opaque minerals. A cursory examination of the heavy minerals present revealed a dominance of magnetite with much chromite and smaller amounts of pyrite, galena, chalcopyrite, garnet (probable), osmiridium (probable but very rare), and possibly ilmenite. The tremolite-actinolite grains do not have a clastic appearance and it is considered highly unlikely that this mineral could have been deposited clastically in its present form. The tremolite-actinolite is interpreted as an alteration product of clastic pyroxene crystals derived from the partially serpentinized pyroxenites occurring in the underlying ultrabasic complex. If this explanation of the composition of the basal Junee Group is accepted then this implies that the ultrabasic complex was emplaced in pre-Ordovician times and exposed at the surface during the Ordovician.

The complex has previously been regarded as Devonian in age and intruding the sediments now correlated with the Junee Group (Reid, 1919; Taylor, 1955), this conclusion being mainly based on the local areas of silicification of the basal Junee Group where it lies on the complex, e.g., the creamy chert at 720E 243N. The presence of this silicification (which is adjacent to a major Devonian fault line) does not refute the presence of an unconformity. Silicification may be due to post-Ordovician hydrothermal activity in the ultrabasic complex.

Blyth's Creek Formation.

The Blyth's Creek Formation is defined as the friable quartz sandstone formation conformably or disconformably overlying the Dally's Siltstone and conformably overlain by the Cabbage Tree Conglomerate. The typical exposures occur near 766E 236N adjacent to Blyth's Creek from which the formation is named.

The formation is about 100′ thick and consists of coarse, quartz sandstones, generally yellow or pinkish in colour and containing a small amount of muscovite. The sandstones are typically not silicified and tend to be rather friable. West of the quarry at 766E 236N are fine conglomerate and grits, lenticular and very thin. The quarry at 766E 236N was opened on limestone, probably no more than 20 feet thick and apparently white and recrystallized. The formation resembles the Junee Group rather than the Cambrian System in lithology, but there is no fossil evidence to indicate the age. The lithology is completely different from the Jukes Breccia which underlies the Owen Conglomerate in other parts of Tasmania. There is a possible disconformity between the formation and the underlying Dally's Siltstone but there is no evidence of unconformity.

At 7566E-2280N friable, unsilicified yellow-brown quartz sandstones occur conformably below the typical Cabbage Tree Conglomerate and merge into it. No limestone could be found but these beds are probably the Blyth's Creek Formation. Further north on Cabbage Tree Hill there is no surface evidence of the Blyth's Creek Formation but Twelvetrees (1903) reported a thin limestone encountered on the 700 feet level, west of the Tasmania Mine (746E 254N) and again on the 800 feet level of the Wonder Mine (738E 258N). The position of this limestone seems to be about 130 feet above the Ilfracombe Slate, within sandstones that are commonly pyritic and below the typical Cabbage Tree Conglomerate. It is inferred that the Blyth's Creek Formation is present in this area, is 150-200 feet thick, and lies conformably between the Ilfracombe Slate and the Cabbage Tree Conglomerate.

The Blyth's Creek Formation may or may not be present below the Cabbage Tree Conglomerate on Blue Peaked Hill and overlying the ultrabasic complex near grid line 720E. However, in the road section near 711E-263N friable sandstones occur below the typical Cabbage Tree Conglomerate, and may be equivalent to the Blyth's Creek Formation. The significance of the basal impure sandstone in deducing unconformity in this area has already been discussed.

Cabbage Tree Conglomerate.—As with the Blyth's Creek Formation, the Cabbage Tree Conglomerate occurs in four separate areas and structural environments and in each of these has certain different features.

The most easterly belt of Cabbage Tree Conglomerate outcrops at 765E-246N and further south at 782E-213N. The formation is about 20 feet thick and consists of quartzites (highly siliceous, recrystallised and with some quartz veining) with occasional fine quartz grits. The quartzite contains small chromite grains.

The Cabbage Tree Conglomerate (Johnston, 1888; Twelvetrees, 1900) on the Cabbage Tree Hill-Blue Tier ridge is well exposed in a road section at 757E-228N. The formation is here about 200 feet thick but both the top and base of the formation are gradational. Grey to black quartzites and quartz grits are dominant but there are occasional thin beds of black shale and, towards the base, fine conglomerates become common, some with pebbles up to 2-3 inches. There are occasional quartz breccias in the lower part of the formation and in these white chert fragments are very common. Chromite grains are common on a number of horizons, all low in the sequence. Many sandstones in the upper part of the sequence are tubicolar. The formation is generally thick or massive bedded and current bedding is common.

The Cabbage Tree Conglomerate further north on Cabbage Tree Hill changes in thickness although the lithology remains fairly constant. At the Tasmania Mine this formation is 600-700 feet thick.

The structure on Blue Peaked Hill is a north-plunging asymmetrical anticline. Owing to the possibility of minor folding and the uncertainty of the exact position of the base of the formation the thickness cannot be measured accurately. However, the thickness, assuming no minor folding, seems to be about 2,900 feet on the north-eastern flank of the anticline, and on the western limb, close to the fold axis, about 1,000 feet. The lithology of the formation on Blue Peaked Hill is somewhat different and two members were mapped. The lower member contains very siliceous quartzites, grits and conglomerates similar to those low in the Cabbage Tree Hill sequence. In the upper member tubicolar, non-recrystallized quartz sandstones are dominant; flaggy quartz sandstones are common but grits are very rare. There is a striking vegetation difference between the two members as the soil is very siliceous and apparently infertile on the lower member.

Along the south-eastern margin of the ultrabasic complex the Cabbage Tree Conglomerate is represented by about 250 feet of grey quartzites and tubicolar sandstones. Grits are absent or very rare and the formation becomes more micaceous towards the top, finally passing gradationally into the Caroline Creek Sandstone.

Further north at 711E-263N the Cabbage Tree Conglomerate is 50 ± 5 feet thick and contains grey quartzites showing excellent small scale current bedding, and fine, white, quartz conglomerate with some beds of soft, friable sandstones.

To summarize the features of the Cabbage Tree Conglomerate in the area it can be said that the formation varies rapidly in thickness (fig. 2). The lithology is also rather variable but it typified by its constant highly-siliceous nature, considered to be an original sedimentary feature. The Cabbage Tree Conglomerate is correlated with the Owen Conglomerate because of similar lithology and similarity in stratigraphic position.

Caroline Creek Sandstone.—This formation lies conformably above the Cabbage Tree Conglomerate and below the Gordon Limestone. There is a gradational change in character from the Cabbage Tree Conglomerate quartzites to sandstones and siltstones, generally thin bedded and slightly micaceous, and the base of the formation is arbitrarily chosen as the top of the uppermost grit horizon. As with the other Junee Group formations the stratigraphy of the four separate structural environments must be discussed separately.

At Blyth's Creek (7655E-2460N), overlying the Cabbage Tree Conglomerate, but with about 40 feet of unexposed section between, there is a soft, yellow-brown, fine siltstone with limonitic cavities perhaps due to the former presence of fossils. A thin limestone bed was formerly quarried about 10 yards to the east of this but no outcrop of this could be found. These beds are unlike the typical Caroline Creek Sandstone and they are included here because of their stratigraphic position above the Cabbage Tree Conglomerate.

The Caroline Creek Sandstone is very well exposed along the roadside near 760E-230N. The total exposed thickness is about 650 feet and the actual thickness probably not over 750 feet. The formation has been divided into three members. The lowest member is about 180 feet thick and towards the base consists of brown and off-white, thick and thin bedded, micaceous sandstones lacking the complete recrystallization of the Cabbage Tree Conglomerate. These gradually grade up into darker grey, micaceous quartz sandstones with occasional beds of black shale. Some of the more massive sandstones show a degree of purity and recrystallization comparable to that of the Cabbage Tree Conglomerate. No fossils have been found in the lowest member.

The middle member is about 60 feet thick and there is a gap of 20 feet between its lowest exposure and the top of the lowest member. The member consists of fine quartz sandstones, generally friable, and with variable amounts of clayey matrix. A distinctive dull green siltstone about 4 feet thick is seen in thin section (No. 8,161) to consist of about 30% angular quartz grains set in a chloritic matrix (50%) with irregularly distributed patches of opaque oxides. The prominent feature is the presence (20%) of patches and bands of rounded or very irregularly shaped bodies composed of fibrous, colourless amphibole and often having a well formed spherulitic structure. These bodies were probably primarily of organic origin. The

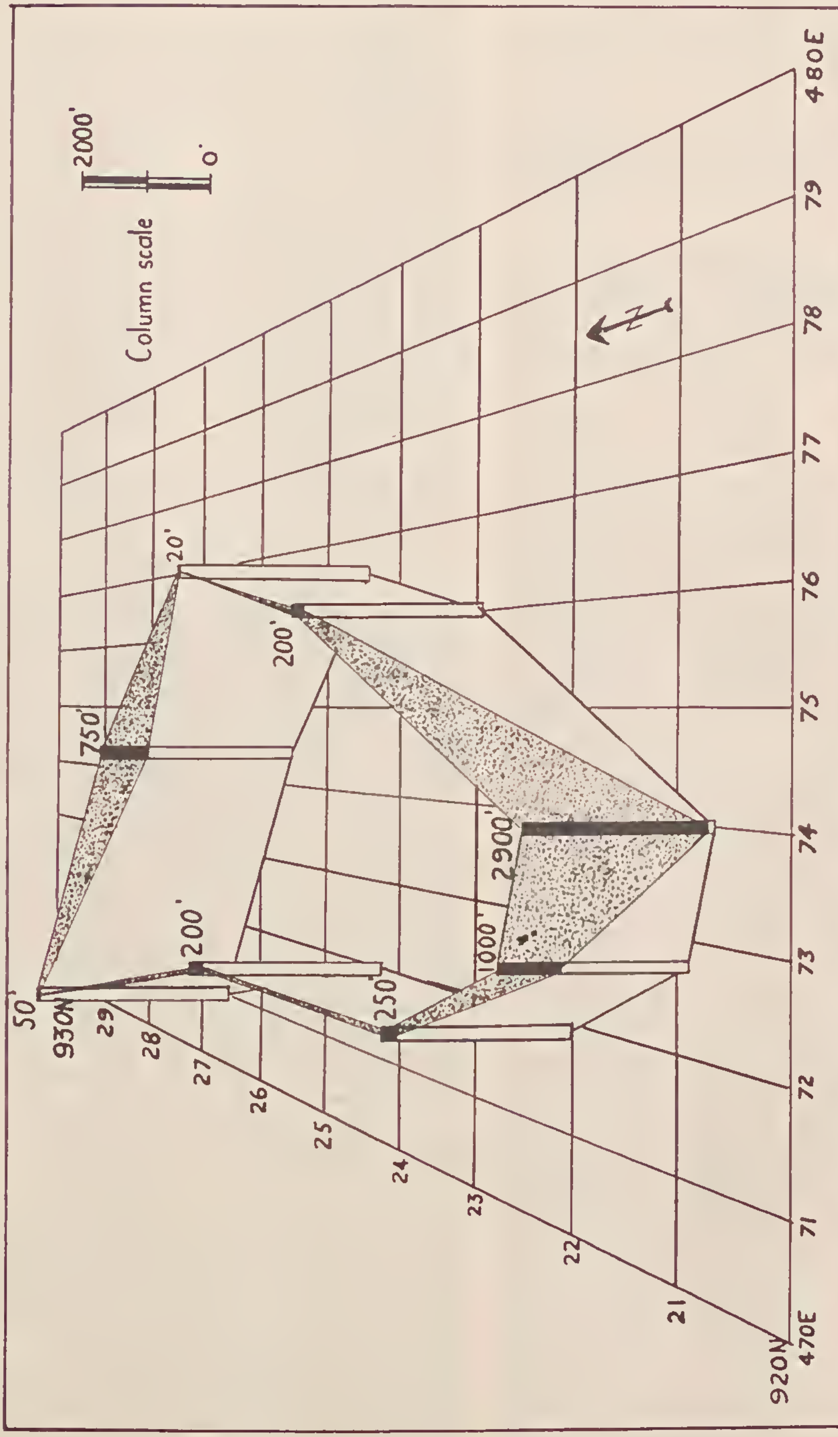

FIG. 2:—VARIATION IN THE THICKNESS OF THE CABBAGE TREE CONGLOMERATE IN THE BEACONSFIELD AREA.

member is quite richly fossiliferous but preservation is poor. The following were identified by M. R. Banks of the Geology Department, University of Tasmania: Hyolithids, an orthid brachiopod, trilobite fragments, cystoid calical plates and echinoderm columnals.

The upper member of the formation is over 400 feet thick and consists of monotonous white and buff-coloured thin-bedded micaceous sandstones and some siltstones. Some beds are fossiliferous but preservation was too poor to make identification possible.

Further north on Cabbage Tree Hill, fossils occur in a mine dump near 735E-267N in material probably from the top of the Cabbage Tree Conglomerate or base of the Caroline Creek Sandstone. The forms identified include *?Tritoechia*, a *Paurorthis*-like brachiopod, and trilobite, cystoid and echinoderm fragments.

East of the ultrabasic complex at 7215E-2420N pale-yellow, thin-bedded micaceous quartz sandstones are overlain by a coarser friable sandstone which is in part richly fossiliferous. The following have been identified: *Tritoechia* sp., an orthid brachiopod appearing somewhat like *Paurorthis*, and the trilobites *Tasmanaspis lewisi* and *Prosopiscus subquadratus*. These trilobites have been recorded from the type locality of the Caroline Creek Sandstone.

Again at 7115E-2635N about 100 feet of thin bedded and flaggy, white micaceous quartz sandstones with lesser siltstones contain poorly preserved fossils, including the *Paurorthis*-like brachiopod, an asaphid trilobite, and cystoid calical plates.

In general, the Beaconsfield fossils are not well preserved, but M. R. Banks considers them adequate to demonstrate a Lower Ordovician age (personal communication).

Leonardsburgh Siltstone

The Leonardsburgh Siltstone is defined as that formation of monotonous black or dark-grey siltstone conformably overlying the Caroline Creek Sandstone and conformably underlying sandstones and shales possibly equivalent to the Grubb Beds. The typical exposures occur near 711E-270N and the formation takes its name from a nearby property. The formation is considered to be a northern and western facies equivalent of the Gordon Limestone in the Beaconsfield area.

In the type area the formation has a well-defined cleavage but bedding is rarely evident. The siltstone is slightly micaceous and yellow-brown on weathered surfaces. The thickness in the area is about 950 feet and the overlying beds include white, fine sandstones and talcose shales. Although the base and top of the formations are not well exposed there is little doubt that the formation forms part of the conformable Junee Group sequence.

At 725E-214N on the western limb of the Blue Peaked Hill Anticline overlying the Caroline Creek Sandstone occur fine, very fissile, black siltstone and a little slate. The siltstones are slightly micaceous and are yellow or yellow-brown when weathered. Though slightly finer grained and more fissile, these siltstones are similar in lithology and stratigraphic position and are correlated with the Leonardsburgh Siltstone.

No fossils could be identified from the formation. The typical exposures at 711E-270N contain very doubtful organic remains.

Gordon Limestone.—The Gordon Limestone conformably overlies the Caroline Creek Sandstone east of Cabbage Tree Hill. The base of the formation is not exposed and the only exposures, at 761E-236N, are at the top of the formation. The formation here is a massive blue limestone, generally completely lacking evidence of bedding but in places showing bedding by the presence of probable algal organisms. The thickness, calculated from the width of the distinctive topographic feature, is about 550 ± 100 feet. The limestone was intersected further north in the workings of the Tasmania Mine, and Montgomery (1891) gave the following section:—

Slate—Grubb Beds

Limestone	Gordon Limestone.	= 60 feet
Slate		= 70 ,,
Sandstone		= 60 ,,
Slate		= 15 ,,
Limestone		= 15 ,,
Slate		= 100 ,,
Limestone		= 200 ,,
	Total	= 520 feet

Light-bluish, grey and yellow sandstones (Caroline Creek) = 400 feet.

There is no evidence that the formation at 761E-236N contains slate and sandstone members and if these are absent then an increase to the north-west in the content of clastic material is indicated. In this eastern area there is no Leonardsburgh Siltstone immediately above the Caroline Creek Sandstone. No outcrops of Gordon Limestone were found in either of the structural lows to the west of Cabbage Tree Hill.

Grubb Beds

This name is given to those beds lying conformably above the Gordon Limestone. Exposures are very rare and occur on Grubb Street, Beaconsfield, at 750E-254N, at 747E-260N, and at 761E-236N.

The two northern exposures consist of fine, white, micaceous sandstones and siltstones somewhat like those overlying the Leonardsburgh Siltstone. Further south the limestone in Dally's Quarry (761E-236N) is overlain by over 200 feet of black, slightly-micaceous slate.

Correlation of the Junee Group.—Due to the lack of fossil evidence, correlation of the formations is mainly based on stratigraphic position and lithology. The exception to this is the Caroline Creek Sandstone, since the fossils found in this formation enable correlation within the area and with the Caroline Creek Sandstone as developed elsewhere in Tasmania.

The Blyth's Creek Formation is newly-defined in the Beaconsfield area. Its stratigraphic position corresponds to that of the Jukes Breccia but it is completely unlike this in lithology.

The Cabbage Tree Conglomerate in the Beaconsfield area resembles the Owen Conglomerate in the type area in its siliceous nature, presence of conglomerate and tubicolar sandstones and in the presence of chromite grains, though these occur within 100 feet of the top of the formation in the Queenstown area and very near the base in the Beaconsfield area. It differs from the type area in the comparative rarity of conglomerates and the dominance of quartzites and grits, and the lack of pink haematite staining.

The correlation of the Gordon Limestone with the rest of Tasmania is based on its characteristic lithology and its stratigraphic position above the Caroline Creek Sandstone. There is no palaeontological evidence to confirm this. The Leonardsburgh Siltstone occupies the stratigraphic position of the Gordon Limestone in the western part of the area and is apparently absent in the south-eastern part. There is also a northward increase in the clastic content of the Gordon Limestone east of Cabbage Tree Hill, and it is likely that the Leonardsburgh Siltstone is a western and northern facies variant of the Gordon Limestone.

The sediments above the Gordon Limestone resemble the Mathinna Group rather than the Eldon Group of Western Tasmania.

Palaeogeography of the Junee Group.—The Cabbage Tree Conglomerate varies rapidly in thickness throughout the area as shown in fig. 2. This variation may reflect the shape of the depositional basin as is implied in fig. 2 or the Cabbage Tree Conglomerate may be a lens-shaped, near-shore deposit which changes along the strike into Caroline Creek Sandstone, Gordon Limestone, and perhaps subgreywacke of the Mathinna Group type. This second interpretation is shown in fig. 3.

There is some evidence which favours the second hypothesis since chromite grains occur in the 20-feet thickness of Cabbage Tree Conglomerate on Blyth's Creek and again near the base of the 200-feet sequence on Cabbage Tree Hill. Accepting the chromite-containing beds as a marker horizon, then the thinning to the east from 200 feet to 20 feet is due to facies change and not to lensing out on a rising basement to the east.

The thinning of the Cabbage Tree Conglomerate to the west is most reasonably explained as a thinning on to a stable source area—the Asbestos Range. There is little increase in grain size to the east, but with the interpretation shown, fine conglomerates were being deposited on the ultrabasic complex while tubicolar sandstones were being deposited further east.

The Caroline Creek Sandstone has a similar pattern of thickness variation and this is interpreted as due to facies change as shown in fig. 3. The Gordon Limestone at Flowery Gully south of Blue Peaked Hill is around 1,700-2,000 feet thick (Noakes, Burton and Randal, 1954) but is only about 500 feet thick east of Cabbage Tree Hill. As shown in fig. 3, this can also be interpreted as due to facies change. The Gordon Limestone is also considered to pass laterally westward and northward into Leonardsburgh Siltstone. Accepting the reconstruction of the Junee Group sedimentation as shown in fig. 3, there are at least 5,000 feet of sediments to the east which are stratigraphically equivalent to the Junee Group. These are seen in the area only as isolated outcrops of

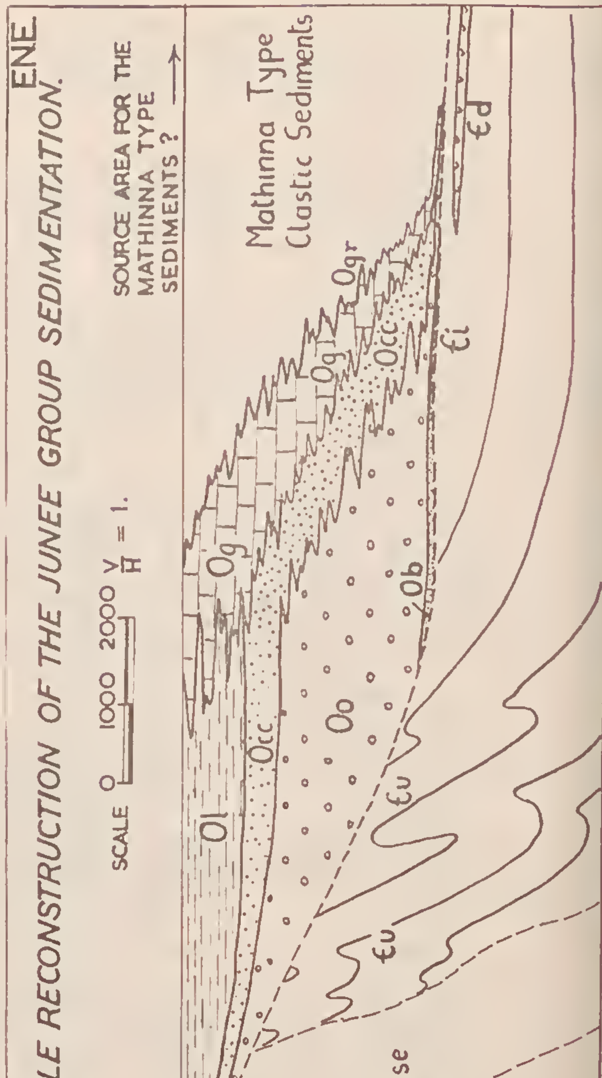

FIG. 3: A POSSIBLE RECONSTRUCTION OF THE JUNEE GROUP SEDIMENTATION.

the Grubb Beds but are probably equivalent in part to the Mathinna Group of north-eastern Tasmania. The source area for these sediments is unknown but does not lie to the west. It is possible that in the eastern part of the area there has been conformable sedimentation, including the Cambrian Dally's Siltstone, the Cabbage Tree Conglomerate (20 feet) and then about 5,000 feet of clastic sediments, probably dominantly of subgreywacke type .

PERMIAN SYSTEM.

A gently-dipping sequence of Permian rocks unconformably overlies Ordovician, Cambrian and Precambrian rocks. The system is almost entirely marine, although the portion actually containing marine fossils is very small. The thickness of the system is variable owing to irregularities of the surface of unconformity but is of the order of 1,700 feet.

Along the shores of Middle Arm there is very good exposure of the most eastern area of Permian sediments but the sediments unconformably overlying the ultrabasic complex in the northern part of the area are poorly exposed and, with the exception of the Darlington Limestone, correlation with the Middle Arm section is not possible. No evidence of the Liffey Sandstone, the distinctive third and fifth members of the Woodbridge Formation or the Garcia Formation was found. It is likely that the Liffey Sandstone at least has lensed out in the northern area. In the southwest corner of the area basal Permian breccias and conglomerates overlie the ultrabasic complex and the Precambrian rocks. Correlation of these beds with the rest of the area is again not possible and it is possible that a Permian shoreline existed to the west parallel to the Asbestos Range causing a change in sedimentation in this area.

Quamby Siltstone (Wells, 1957).—The Quamby Siltstone is the lowermost Permian formation in the Beaconsfield area. Exposure is not good but the formation consists of up to 850 feet of monotonous blue-grey and grey micaceous siltstones, very poorly fossiliferous and containing a varying abundance of erratics. The basal beds are probably richer in erratics but there is no evidence of any till below the siltstone. In general the erratics are sparse and are commonly perfectly rounded. Rare fossils include spiriferids, *Stenopora* and ostracodes. Two very significant features of the formation are the presence of large (up to 6 feet x 3 feet x 3 feet) calcareous concretions on certain horizons and the presence of probable glendonites in association with them.

The character of the top of the formation is not clear but it probably includes blue-grey fossiliferous siltstones, rich in erratics, in the upper 40 feet and finally about 5 feet of yellow shales, rich in fenestrate bryozoans.

Darlington Limestone.—This formation is 4 feet thick and consists of rather pure limestone interbedded with black calcareous shales, in which erratics are especially common. The limestone is richly fossiliferous and contains *Stenopora*, fenestrate bryozoans, "*Martiniopsis*", several spiriferids, common *Strophalosia* sp. and occasional gastropods. *Eurydesma cordatum* occurs in clusters and is generally convex upwards. Common *Calcitornella* sp. supports correlation with the Darlington Limestone.

Swift's Jetty Sandstone.

The Swift's Jetty Sandstone is defined as that formation of fossiliferous, erratic-rich sandstone with interbedded shale lying conformably above the Darlington Limestone and below the Liffey Sandstone. The typical exposures occur near 767E-263N and the formation takes its name from the old jetty at 766E-268N.

The formation is approximately 50 feet thick. The lower 25 feet consist of coarse, poorly-sorted dark-grey sandstone containing common erratics, some up to 18 inches long, usually smooth and rounded but in some cases very angular and faceted. Interbedded with the sandstones and becoming dominant towards the top of the formation are yellow and buff-coloured shales and fine siltstones. Fossils are common throughout the formation, and include large spiriferids, *Strophalosia* sp., *Keenia ocula*, and uncommon *Eurydesma*. *Stenopora*, fenestrate bryozoans and crinoid columnals occur in the finer grained beds.

The Darlington Limestone and Swift's Jetty Sandstone together are equivalent to the Golden Valley Formation of Wells (1957), and the Golden Valley Group of McKellar (1957), excluding the Quamby Mudstone.

Liffey Sandstone (Wells ,1957).—The base of this formation does not outcrop but its thickness is approximately 10 feet near Swift's Jetty. It is probable that the formation becomes thicker towards the south-east. It contains sandstones ranging in composition from quartz, quartz-mica to quartz-mica-graphite and varying from thick-bedded to thin-bedded and flaggy with low angle current bedding.

The absence of marine fossils and erratics and the presence of common graphite strongly suggests a fresh-water origin for the beds.

Woodbridge Formation (Prider, 1948; Wells, 1957).—This formation is approximately 70 feet thick and contains a variety of lithologies. The basal member is a 5-feet grey-white sandstone containing abundant tubular bodies (worm casts?). At the base of this a 3-inch band rich in erratics rests abruptly on the Liffey Sandstone. The nature of the contact suggests a disconformity.

The second member consists of about 20 feet of grey sandstones with abundant erratics often occurring in clusters. Fragmentary fossils are particularly common in the upper part of the member. These fossils also tend to occur in clusters and include spiriferids, rare *Strophalosia*, *Stenopora* and *Dielasma*. This member is overlain abruptly by a thickness of 5 feet of calcareous siltstone characterized by the abundance of fenestrate bryozoans. A rich pelecypod fauna is also present but forms are usually small and confined to certain bands. Pelecypods include *Astartila* and *Stutchburia*. *Stenopora crinita* and other species, *Hyolithes lanceolata*, *Mourlonia* and other gastropods, spiriferids and *Dielasma* are also present.

The fourth member is about 25 feet thick and changes gradually from a blue-grey siltstone with rather common erratics to yellow-brown fine sandstone rich in erratics but apparently non-fossiliferous. This is overlain by the fifth member which is a yellow, bryozoal shale grading upward into a richly-fossiliferous sandstone. In this the fossils are preserved only as moulds, contrasting with the original shell material preserved in lower beds. Fossils present include *Polypora*, *Fenestella* sp., *Stenopora* sp., *Dielasma*, alate spiriferids, including *Neospirifer*, large and small pectens and other pelecypods, and small gastropods.

The Woodbridge Formation has not been split further into Meander, Dabool and Weston Formations as has been done by McKellar (1957) in the Palmer River area. This is impracticable as the lithologies and thicknesses in the Beaconsfield area are rather different. However, the 10-feet Creekton Sandstone which McKellar places in the Liffey Group is apparently very like the 5 feet of worm-cast sandstone at the base of the Woodbridge Formation in the Beaconsfield area. If this correlation is correct, then the Creekton Sandstone should probably be placed in the Woodbridge Formation in view of the probable disconformity at its base.

Garcia Formation (McKellar, 1957).—This formation is 10 feet thick and overlies the Woodbridge Formation extremely abruptly with 6 inches of coarse breccia at the base containing large, angular, faceted boulders in a sandy matrix. The breccia is consecutively overlain by 3 feet of poorly-sorted, erratic-rich sandstone, a 2-feet bed with fine, blue-grey sandstone laminae separating layers of bright yellow clay; 2 feet of blue-grey siltstone, and 3 feet of grey-white, worm-cast sandstone. McKellar (1957) includes in the base of the Garcia Formation horizons containing marine fossils but in the Beaconsfield area the base is taken at the base of the breccia overlying the fossiliferous Woodbridge Formation .

**Springmount Siltstone* (McKellar, 1957).—This formation is about 255 feet thick and, except for a 1-foot bed of hard grey-white siltstone 6 feet above the base, the formation consists of monotonous, grey-blue and light-grey, slightly micaceous siltstones becoming faintly pink towards the top. The formation is generally thinly-bedded, a shaley parting is commonly present, erratics are rare and generally well rounded, fossils are apparently completely absent.

Palmer Sandstone (McKellar, 1957; Wells, 1957).—At the top of the Springmount Siltstone at 774E-273N, a 6-inch bed of coarse grit and common, large, faceted pebbles abruptly overlies a limonite-stained surface of fine siltstones. It is probable that this represents a disconformity in the sequence. Overlying this basal grit are 6 feet of white quartz sandstones, poorly sorted and with fairly common though irregularly distributed erratics. Worm casts (?) are frequent and may be parallel or inclined to the bedding. They are commonly branching and often appear segmented. The sandstone is overlain by 6 feet of yellow-pink, sandy siltstone with shaley parting but lacking erratics and worm-casts. This, again, is abruptly overlain by 9 feet of massive white sandstone containing common grit and a few erratics.

Bowen's Jetty Sandstone.

The Bowen's Jetty Sandstone is defined as the formation of erratic-rich, poorly-sorted unfossiliferous sandstones and siltstones lying conformably above the Palmer Sandstone and below the Blackwood Conglomerate. The typical exposures occur in the vicinity of Bowen's Jetty 764E-290N, and on the eastern shore of Middle Arm.

The formation is 400 feet thick and consists of sandstones and siltstones. The latter are generally blue-grey in colour and similar in lithology to the Springmount Siltstone. The sandstones vary somewhat but are commonly white or creamy coloured, poorly-sorted quartz sandstones, rich in erratics and lacking fossils. The formation corresponds in stratigraphic position to the Dry's Mudstone (McKellar, 1957) but is different in lithology.

Towards the base is an alternation of blue-grey non-fossiliferous siltstones and grey-white, erratic-rich, poorly-sorted sandstones containing many worm-casts. About 300 feet from the base sandstones are dominant and are commonly limonite-stained and contain limonitic concretions. Above these are 60-70 feet of sandstones containing common erratics, including gneiss, granite, several silicified tree trunks and a variety of quartzite and slate fragments. There are 4 feet of white shales immediately below the Blackwood Conglomerate.

Blackwood Conglomerate (McKellar, 1957).—Good exposures of this formation occur on the shore platform at 773E-284N. The formation is 2 feet thick and consists of a single bed of fine quartz conglomerate. The pebbles are sometimes up to 5 cms. long but more commonly are 2-5 mm. They are sub-rounded to well-rounded, poorly sorted, and include occasional slate pebbles, although the great majority are of clear, colourless quartz.

The base of the conglomerate rests very abruptly on a limonite-stained surface of a 4-feet shale bed at the top of the Bowen's Jetty Sandstone. It is probable that this surface is a disconformity. The conglomerate is overlain by carbonaceous quartz-mica sandstones of the Clog Tom Sandstone. It seems quite clear in this area that the Blackwood Conglomerate marks the stratigraphic break between the marine Bowen's Jetty Sandstone and underlying formations and the freshwater Clog Tom Sandstone and the overlying Triassic sandstones.

Clog Tom Sandstone

The Clog Tom Sandstone is defined as the formation of micaceous quartz sandstones overlying the Blackwood Conglomerate and considered to underly the Triassic Sequence. Typical exposures occur on the eastern shore of Middle Arm. The formation takes its name from Clog Tom Creek which flows into the south eastern corner of Middle Arm.

The thickness of the formation is unknown as it is faulted against the Triassic sandstones. Carbonaceous material, including leaves and twigs, is common but poor preservation prevented identification. The formation may be Permian or Triassic in age. Wells (1957) considered that a breccia apparently similar to the Blackwood Conglomerate marked the base of the Triassic Sequence, but McKellar (1957) recorded the Eden Formation resembling the Permian sediments from above the Blackwood Conglomerate and thus in a similar stratigraphic position to the Clog Tom Sandstone.

TRIASSIC SYSTEM.

The beds lying on the downthrown side of a fault in the north-eastern corner of the area are possibly Triassic in age. Their thickness is unknown but they probably conformably overlie the Clog Tom Sandstone. The beds consist of yellow sandstones, dominantly quartzose but with abundant mica; grit lenses are not uncommon, and grey shales, weathering pink, are also present.

* The Springmount Siltstone, Palmer Sandstone and Bowen's Jetty Sandstone have been grouped together and shown on Plate 1 as their Southern Tasmanian correlate, the "Ferntree Mudstone".

Bedding is generally very irregular with current bedding, common scouring and deposition of clay pellets. Carbonaceous material is generally absent and no fossils could be found. The intrusion of the Triassic sandstones by the large dolerite mass to the east has produced only minor baking of the sandstone.

Jurassic System.

In the Beaconsfield area dolerite, probably Jurassic in age, invaded Palaeozoic (including Permian) and Triassic sediments. The major dolerite intrusion (on Long Point) is a discordant north-easterly dipping body which trends north-west parallelling the major Tabberabberan trends and most probably controlled by them. There is a fine-grained margin exposed at 771E-292N but the major part of the intrusion is medium to coarse-grained dolerite containing approximately equal proportions of zoned plagioclase (Ab_{44} An_{56} at the core to Ab_{65} An_{35} at the crystal edges), pyroxenes (augite and pigeonite), and mesotasis (fine-grained areas of chlorite, opaque oxides, quartz, apatite and feldspar).

Cretaceous System

No rocks which can definitely be assigned to the Cretaceous Period occur in the Beaconsfield area. However, it is possible that the ironstone surfaces, particularly on the ultrabasic complex, were formed during the Cretaceous or early Tertiary Periods. Extensive areas of ironstone gravel occur on the ultrabasic complex and the limits of this material are shown, as well as their indefinite nature will allow, on B. L. Taylor's (1955) map of the Anderson's Creek area. On Scott's Hill, Mt. Vulcan and Barnes' Hill occur thick deposits (around 50 feet) of concretionary limonite, haematite and magnetite resting on serpentinite containing common magnetite veinlets. These deposits have been described and their economic aspects discussed by Twelvetrees and Reid (1919) and Nye (1930).

The ironstone areas are at present being eroded by Anderson's Creek and it is likely they were formed before the Tertiary faulting at the northern end of Anderson's Creek. The rather great thickness of some of these ironstone cappings suggests a long period of weathering accompanied by little or no erosion.

Smaller areas of ironstone developed on the Caroline Creek Sandstone near Brandy Creek may be Cretaceous in age but are more probably Tertiary or Quarternary.

Tertiary System.

Although outcrop in the northern and north-eastern parts of the area is very poor, a considerable portion of the area is considered to be covered by Tertiary lacustrine sediments. In a quarry at 730E-275N thin-bedded, unlithified sandy clays, fine and coarse sandstones and thin grits dipping up to 32° N.E. unconformably overlie the Cabbage Tree Conglomerate. These in turn are overlain with slight unconformity by very coarse conglomerate consisting of well-rounded and generally well-sorted quartz and quartzite pebbles set in an abundant limonite-stained sandy matrix. This conglomerate, with interbedded sandy lenses, outcrops spasmodically over a rather wide area and seems to occur at a number of levels in the Tertiary sequence.

The deep lead at the foot of the eastern slopes of Cabbage Tree Hill contains varicoloured clays alternating with narrow bands of sand, grit and sandstone rubble to a depth of 364 feet (220 feet below sea level) as shown by a bore hole at 746E-255N (Scott, 1930). The continuation of the deep lead north and south of Beaconsfield cannot be traced definitely. The northerly continuation could underlie the Tertiary sediments and may in fact continue in any direction between north and north-east from a point near 740E-265N to join the present Tamar River in the vicinity of Beauty Point. The only part of the area south, west, or east of Beaconsfield in which pre-Tertiary rocks do not outcrop at heights above sea-level is the belt of Gordon Limestone west of Dally's Quarry and the belt of recent alluvium at the foot of Blue Tier. If the deep lead does continue through this area then in early Tertiary time, assuming the base of the deep lead to be at about 200 feet below sea-level, there must have been a 300-feet gorge with the eastern wall composed of Gordon Limestone on a slope greater than 45°.

The alternatives to this hypothesis would require the deep lead both to enter and leave the area in its north central part. Another possibility is that the "deep lead" is actually one of several very deep sink holes (360 feet in depth) in the Gordon Limestone at the foot of Cabbage Tree Hill.

At 742E-255N, on the slopes of Cabbage Tree Hill, unconsolidated sediments, believed to be Tertiary, and dipping at 10° north-east, occur at 300 feet. It is likely that the whole area east and north-east of Beaconsfield was once covered to a similar height with Tertiary lacustrine sediments. The surface probably sloped gently to the north-east and continued further to the south-west and west on the western side of Cabbage Tree Hill.

Tertiary Basalt.—In the northern part of the area basalt occurs as scattered outcrops between 744E-288N and 752E-299N. The basalt is 50-60 feet thick and the top is fairly constant in height at 190-200 feet. The base appears irregular but this is due to landslips rather than irregularities in the base of the flow itself. The basalt overlies Tertiary sediments, including limonitic sandstones with poorly preserved leaf impressions and is overlain by quartz gravels.

The basalt is massive, non-columnar and in thin section consists of about 45% plagioclase (labradorite Ab_{37} An_{63}), 15% olivine, 30% pyroxene and 10% opaque oxides (probably mainly ilmenite). The texture is porphyritic with three distinct size ranges. The olivine occurs in phenocrysts up to 2 mm. long, the labradorite as interlocking laths ½ mm. long and sometimes showing alignment due to flowage, the ilmenite as similarly sized irregular elongate grains and the pyroxene as tiny, irregular intergranular grains. There are also very small amounts of colourless, isotropic glass and some chlorite forming the very rare patches of mesostasis. The olivines show alteration to magnesite and serpentine.

Post-basaltic Gravels.—The post-basaltic white quartz gravels of the northern part of the area form a gently undulating surface falling from 430 feet at the south-western limit (715E-245N) to 200-250 feet in the northern part (745E-295N) and 100 feet in the north-western area (700E-295N) and (715E-295N). The gravels are variable in character but in general are only a thin veneer on underlying formations.

The angular, poorly-sorted gravels west of the concealed strike ridge of the Cabbage Tree Conglomerate near 717E-251N are considered to have been derived from this formation. The extensive belt of gravels between 717E-251N and the Cabbage Tree Conglomerate at 732E-272N probably has a similar origin. These gravels are dominantly angular with little evidence of transport and overlie a limonitic subsoil. In several places, e.g., 722E-259N, the gravel overlies a black peaty earth. In the vicinity of 732E-272N extensive removal of quartz gravel for building purposes has shown that the quartz gravels are only 2-3 feet thick and apparently have resulted here from weathering *in situ* and removal of fine material from the Cabbage Tree Conglomerate.

Near 721E-278N there are several horizons in the gravel containing quite large (3-6 inches) well rounded quartzite boulders—these appear rather like a shore line or storm beach deposit and are about 100 feet above sea-level.

In the northern area near 745E-295N the gravels may be up to 50 feet thick and vary from poorly sorted to well sorted, the latter increasing towards the top of the sequence. The lower gravels commonly have ½-1-inch pebbles in them but the higher gravels are finer grained and white quartz sand is present in a few areas. The sand grains are of milky-white quartz, generally sub-rounded to angular but showing evidence of water transport in being smooth and sorted.

Quaternary System

Recent Series.—Outcrop is generally very poor in the Beaconsfield area and areas of deep soil cover are extensive. The broad alluvial flats west of Cabbage Tree Hill and Blue Tier and also west of Blue Peaked Hill consist of grey soils containing occasional quartz or quartzite pebbles. Occasional thin beds of river gravel and conglomerate are present near some creeks, particularly Anderson's Creek.

PETROLOGY OF THE METAMORPHIC ROCKS.

The Settlers Metamorphosed Greywacke.

This rock, more resistant to weathering than the enclosing serpentinite outcrops on a number of hills in the northern part of the ultrabasic complex, including a north-east trending ridge at 703E-255N known as Settlers Hills. The rock is medium-grained, holocrystalline, dark to light-grey consisting predominantly of quartz, albite and biotite with lesser chlorite, muscovite and epidote. The proportions of the main constituents (particularly biotite) vary somewhat in different exposures but the rock in hand specimen is remarkably uniform. A well-defined schistosity is evident in some specimens but no bedding or sedimentary structures can be seen in the field.

Twelvetrees (1917) quoted the opinion of Dr. E. W. Skeats who examined thin sections of the rock and concluded "it was originally a rather coarse-grained sediment containing quartz, aluminous or argillaceous material and some partly decomposed feldspars". Reid (1919) favoured an igneous origin apparently on the evidence of the so-called aplites (albitites and gabbros) in the vicinity and on the massive, uniform nature of the rock. Taylor (1955) also called the rock a "syenite" and explained its origin by granitic magma intruding the pyroxenite, dissolving it in part and thereby increasing the magnesia and decreasing the silica content of the magma. He considered the schistose margins and massive centres developed in some of the bodies to be explained by continued intrusion of the magma after partial crystallization at the edges.

Taylor brought forward no petrographic evidence to support his hypothesis of solution of pyroxenite in a granitic magma. If such solution is possible and has occurred, then relict pyroxenes and partial stages in the process should be evident. The author has examined a number of slides (Nos. 8,168-8,174) from different masses of the greywacke, both near and removed from the contacts, and in none of these is there any evidence of the reactions which Taylor implied.

The author considers that the rock is a slightly metamorphosed and recrystallized greywacke composed of similar but variable quantities of plagioclase feldspar and quartzite grains in a matrix of clay and chloritic material with some biotite flakes. The clastic nature is shown in thin section by the quartzite grains which occur as sub-equidimensional, angular to sub-rounded grains generally ½-1 mm. in diameter and consisting of a number of irregularly intergrown crystals. Most quartzite grains show strain effects. The plagioclase occurs as rounded and sub-rounded grains, generally completely sericitized but in some places having a thin rim of clear albite. Clear fine-grained albite also occurs in small veinlets but this secondary albite was observed near the margin of the greywacke mass and not towards the centre. The secondary albite is probably derived from the ultrabasic complex and of the same origin as the albitite bodies to be discussed later. The original clastic plagioclase was probably not albite as clusters of epidote crystals within the sericitized grains indicate a more calcic variety. Relict zoning can often be seen. It cannot be said what proportions of the biotite flakes are clastic but many are bent, somewhat frayed, chloritised and commonly partially bleached.

In the centre of the larger bodies the thin sections show distinct clastic texture but towards the margins the clastic texture becomes less evident due to the coalescing of several sub-rounded quartzite grains into an enlongate oriented composite grain and to the growth of biotite and albite rims. Dimensional orientation of micas is readily evident although no petrofabric study has been made. Shear and crush zones are commonly developed.

To summarize briefly, the author considers that the eight separate bodies of metamorphosed greywacke have resulted from the deformation under low or moderate temperatures of a greywacke sediment containing clastic quartzite, plagioclase (perhaps zoned oligoclase), biotite and clay material. Accessory minerals such as sphene, apatite, ilmenite and muscovite may or may not be clastic.

Accepting a sedimentary origin for these inclusions within the ultrabasic complex, there remains the problem of the age of the rocks. They could, perhaps, belong to the Precambrian basement and have been brought to their present level as solid inclusions within the ultrabasics. However, greywackes are common within the Cambrian System whereas the Precambrian rocks immediately west of Anderson's Creek consist of quartzites and quartz-sericite phyllites. It is considered more probable that the rocks are of Cambrian age and originally overlay the Cambrian sediments to the west of the ultrabasic complex.

Simmonds Hill Metamorphics.

Taylor (1955) first recorded the presence of these rocks but grouped them with the so-called "syenite" of Settlers Hills. On the crest and south-west slopes of Simmonds Hill (698E-224N) is surface float and sparse outcrop of a variety of rock types ranging from slates and rather soft, black, sheared fine sandstone to heavy, hard gneissic rock types. In thin section all of the rock types show evidence of strong deformation with mortar texture, dimensional grain orientation, compositional banding, strain shadows and bending and fracturing of the several minerals present.

Specimen 8,152d is distinctly banded with one band consisting of sericitised feldspar (probably albite) and quartz, another almost completely of quartz in mortar texture and others containing varying proportions of clinopyroxene (diopside), green hornblende and minor amounts of chlorite, biotite and opaque oxides. The grain-size is very variable.

Specimen 8,152c is similar but of finer grain and again consists of albite (some very clear and fresh, Ab_{95} An_{5}) quartz, diopside, grossular; lesser amounts of hornblende, sphene, and opaque oxides; and muscovite, apatite, tremolite and chlorite as accessory minerals. The grain size is again very variable but a distinctive feature is the presence of large grains of pyroxene poikilitically enclosing unoriented hornblende crystals. The hornblende has a similar relation to small muscovite, tremolite, &c., flakes.

Both rocks described above probably belong to the amphibolite facies; the texture is gneissic and they have apparently been formed under moderate to high temperatures and strong stress conditions. The nature of the original rock type is unknown.

Section 8,152b is a finely-banded, fine-grained amphibolite containing green hornblende (50%), quartz (20%), small colourless crystals which may be pyroxene, limonite and a fine-grained indeterminate matrix probably containing tremolite-actinolite, sericite and quartz. This was possibly subjected to slightly lower temperatures than the preceding examples.

The field and microscopic examination of these rocks shows that they are not "syenites" in any sense of the term but consist of low and medium grade metamorphic rocks possessing the common feature of very strong deformation effects. Mineralogical composition is very variable and little can be said regarding the original rock types except that they may have been members of the eugeosynclinal suite of rocks. The obvious agent of metamorphism is the ultrabasic complex which surrounds the metamorphic rocks on at least three sides. The deformation, like that of the Settlers Metamorphosed Greywacke, is probably due to differential movement between the ultrabasic rocks and the metamorphics. The cataclastic mortar texture of specimens 8,152c and 8,152d is an indication that some or all deformation occurred after the main crystallization of the metamorphics had ceased.

PETROLOGY OF THE IGNEOUS ROCKS.

DALLY'S SILTSTONE-KERATOPHYRE MEMBER

The keratophyre member of Dally's Siltstone outcrops quite strongly on a sharp terrace level from near 767E-234N to 778E-218N. In the field the rock is massive, although some exposures have a poorly-developed cleavage. There is no field evidence to decide conclusively whether the body is a sill or a lava flow. Some specimens are vesicular and the sediments below the keratophyre may be baked.

In hand specimen the rock is dark or light-grey with occasional patches of dark-green chlorite and common larger areas and veinlets of pale green epidote. Thin sections Nos. 8,150, 8,151, and 4,620 (1, 2, and 3) show that the rock consists of euhedral albite (Ab_{97} An_{3}), more or less sericitized, in a fine-grained matrix now apparently composed of chlorite, tremolite-actinolite, sericite and epidote. The albite laths are in some cases aligned as if due to flowage (4,620-2). Epidote may form up to 40% of the rock and generally occurs in medium and large-sized, irregular, composite grains commonly with a clear centre and a turbid, finer-grained margin.

The original rock contained some 10%-15% diopsidic or augitic clinopyroxene. This mineral has been partially or completely altered to pennine with lesser sphene, pale-green amphibole or biotite. The original clinopyroxenes were generally zoned and formed stubby, euhedral crystals now replaced by fine-grained chlorite in which relict zoning can be seen. Section 4,620 (2) shows very clearly the genetic relationships between the clinopyroxene, amphibole and chlorite (fig. 4).

The clinopyroxene is primary—it has a euhedral outline towards the matrix and is turbid, whereas the chlorite and amphibole are clear and fresh. The pale-green amphibole occurs as partly or completely formed diamonds with sides bounded by the amphibole cleavages. All the tiny diamonds of amphibole within the boundaries of the one pyroxene grain have exactly the same orientation. It is apparent that the crystallographic orientation of the pyroxene determines directly the crystallographic orientation of the amphibole and the amphibole is secondary. The chlorite appears to be completely random in orientation or else in a poorly-developed type of mesh texture. The most perfectly formed diamonds of amphibole occur when completely surrounded by chlorite. Amphibole occurs within the pyroxene but in these areas is finer-grained and, although it tends to form diamonds, these are seldom well developed.

FIG.4:—RELATIONSHIP BETWEEN CLINOPYROXENE, AMPHIBOLE & CHLORITE IN THE KERATOPHYRE WITHIN THE DALLY'S SILTSTONE (SKETCHED FROM SECTION 4620 (2).)

The following history of the rock is proposed to explain these observations. The primary clinopyroxene (augite or diopside) was zoned and had a number of irregular fractures crossing it. At some stage after initial crystallization, alteration to amphibole began and was localised firstly along the irregular fractures within the pyroxene and secondly in certain favourable zones, particularly the core of the crystal . The amphibole, as it formed, was rigidly controlled in orientation by the orientation of the clinopyroxene and tended to develop euhedral forms presumably because certain planes within the amphibole grew parallel to existing planes within the pyroxene. The amphibole developed more rapidly in certain zones so that well-formed euhedral crystals resulted in one part and tiny, poorly-formed crystals, still with the same orientation, developed in another. Had the physical conditions remained constant long enough the alteration of the euhedral clinopyroxene to euhedral amphibole could have continued to completion. However, as soon as the conditions changed significantly so that the favoured breakdown reaction was not pyroxene to amphibole but pyroxene to chlorite then the formation of amphibole presumably ceased.

In the specimens examined there is no evidence that the amphibole had any tendency to alter to chlorite. Rather, it seems that the relict pyroxene, not previously altered to amphibole, broke down directly to chlorite. This alteration was localised in the same areas in the pyroxene crystals as was the alteration to amphibole with the result that the well-formed amphibole crystals occur surrounded by the chlorite.

The keratophyre was originally a pyroxene andesite containing 10-20% of large, euhedral phenocrysts of clinopyroxene with 60-70% of smaller crystals of calcic plagioclase set in a fine-grained matrix of feldspar and pyroxene or amphibole. The pyroxene andesite has since been extensively altered, the calcic plagioclase being converted to epidote and albite and the pyroxene partially altering to amphibole but mainly to chlorite. Sericitization and growth of tremolite-actinolite wisps have occurred to a varying degree.

If this sequence of alteration of the clinopyroxene in the andesite is generally applicable, then an andesite with euhedral clinopyroxene crystals could conceivably alter to a rock containing clear euhedral amphibole. If the original pyroxenes were aligned by flowage then the secondary amphiboles would be similarly aligned. This may explain the origin of the hornblende andesites from the Langdon River, West Coast of Tasmania, about which there is controversy as to the primary or secondary character of the hornblende phenocrysts (Scott, 1954).

THE CAMBRIAN ULTRABASIC COMPLEX.

The exposed length of the ultrabasic complex occurring on the western margin of the area is 4¾ miles but since the belt passes underneath subhorizontal Permian sediments at both its northern and southern ends its actual extent is not known. The greatest width of the belt is 1½ miles. The complex consists of three distinct though related types, namely.—

(a) The ultrabasic pyroxenite and serpentinite;
(b) The gabbroic rocks, including the rodingites;
(c) The albitite suite.

The age of the complex is established as Upper Cambrian. It is unconformably overlain by chromite-bearing Cabbage Tree Conglomerate and this formation (?) disconformably overlies the lower Upper Cambrian Dally's Siltstone in the eastern part of the area. The Dally's Siltstone does not contain chromite grains and is considered to be part of the greywacke sequence that is intruded by the ultrabasic rocks at Anderson's Creek. The intrusion of the complex is considered to coincide with the cessation of greywacke sedimentation and the (?) disconformity below the Cabbage Tree Conglomerate and Blyth's Creek Formation. The complex is apparently located on a hinge zone between the stable Precambrian block (Asbestos Range) to the west and the Cambrian and Ordovician-Silurian sedimentary basin to the east.

(a) *The Ultrabasic Rocks.*—The ultrabasic rocks form about 80% of the complex. No unaltered rock could be found as, in all specimens examined, serpentization has occurred to some extent. The only rocks seen which were not completely serpentinized were pyroxenites.

A typical pyroxenite (8,179a) consists of enstatite grains of average diameter about 3 mm. Alteration to a finely-fibrous mixture of actinolite and serpentine occurs along the edges and cleavage traces of the enstatite. Occasional crystals of clinopyroxene and rare crystals of pale-green, apparently primary, amphibole occur interstitially. There is no evidence of the presence of olivine. Specimen 8,179b differs from the preceding example in containing about 50% clinopyroxene (diallage ?) with rare bastite pseudomorphs after orthopyroxene, set in a matrix of fine-grained antigorite serpentine. The rock is apparently banded as part of the section contains bastite pseudomorphs to the exclusion of clinopyroxene. If the antigorite matrix was originally olivine then the rock could be classed as harzburgite interbanded with wehrlite; if the antigorite has replaced orthopyroxene then the rock contained bands of orthopyroxenite and websterite. Specimen 8,179c is completely serpentinized and contains 10% brown chromium spinel in mesh texture serpentine showing partial alteration to antigorite. If mesh texture serpentine can only form from olivine and not from orthopyroxene then the original rock was a dunite. However, no relict olivine now remains.

Several rather unusual serpentinites were examined in thin section. Specimen No. 8,175 from 713E-223N is a pale greenish-pink serpentinite with small veinlets of bright green garnierite (identified by X-ray diffraction) and occasional dark-brown grains with adamantine lustre. These were identified by an X-ray diffraction photograph as chrome-picotite. The serpentinite has a mesh texture in which one set of opposite sides of the mesh is strongly developed while the second set is poorly developed or absent. The garnierite occurs as thin colloform veinlets with a central filling of opaline silica. The garnierite and opal are low temperature deposits perhaps due to downward-moving ground waters. There is no sign of any primary nickel mineral in the specimen.

Specimen No. 8,180 from 7,090E-2,645N contains red-brown euhedral amphibole pseudomorphs in a very fine grained matrix of chrysotile serpentine (Film I, Appendix). The amphibole pseudomorphs consists of a chlorite or serpentine mineral heavily flecked with (?) magnetic dust although in half of the thin section these pseudomorphs have pennine rims or are completely replaced by irregular clear pale-brown pennine. The original rock type is problematical as the only rocks seen in the area which contain euhedral hornblende are the hornblende gabbros from 694E-277N.

The greater part of the serpentinite appears to be of bastite and mesh texture type and antigorite is not common. However, at 691E-270N antigorite serpentinite (Specimen 8,178) occurs adjacent to gabbroic rocks and metamorphism by these may account for its formation as Wilkinson (1953) and Hess, Dengo and Smith (1952) have shown that antigorite forms under conditions of low-grade metamorphism.

(*b*) *The Gabbroic Rocks.*—The gabbroic rocks outcrop as small bodies within the complex but are particularly common along the western margin. This western belt is shown in fig. I as a continuous body but outcrop is limited and the true nature is probably a large number of small dykes similar to those exposed near 698E-242N.

The gabbros show considerable variation, especially in their degree of alteration but, with the exception of the distinctive hornblende gabbro (Specimen 8,153) from 694E-277N, the primary rock appears to have been a medium-grained pyroxene gabbro. Clinopyroxene (probably augite) is present as relict cores showing partial alteration to chlorite or tremolite-actinolite. No primary or secondary feldspar was found in the normal gabbros but the nature of the secondary minerals is variable.

Specimen 8,158 (695E-255N) is largely composed of a finely-granular mass of (?) clinozoisite with occasional patches of serpentine and chlorite and grains of partially uralitized clinopyroxene. Picotite is an uncommon accessory mineral. Specimen 8,154 (6,945E-2,550N) is divided into two rock types by a linear zone (1.5 mm. wide) of crushing and granulation. One rock consists of about 60% of zoisite and 40% of green actinolitic amphibole and was probably originally a gabbro. The other contains approximately equal proportions of anhedral augite and zoisite and was also originally a gabbro.

Specimen 8,157 (698E-242N) is a garnetized gabbro or rodingite (Benson, 1913) and contains clear, anhedral crystals of clinopyroxene (augite and possibly pigeonite) in a matrix of fine-grained, colourless, clear garnet, serpentine and chlorite. The clinopyroxene is commonly embayed and replaced by a garnet-chlorite mixture. No feldspar is present although indistinct linear structures in the garnet may be relict cleavage. Specimen 8,155 (6,965E-2,380N) is a similar rock in contact with serpentinite. The gabbro consists of relict clinopyroxene with lesser chlorite, serpentine and clinozoisite and about 60% of fine-grained isotropic garnet which seems to have replaced plagioclase feldspar and partially replaced the clinopyroxene. The contact is very sharp but irregular with the irregularities more convex into the serpentinite. There is no shearing parallel to the contact although several shears intersect it. The contact is largely one of turbid garnet against serpentinite but there are occasional clinopyroxene crystals and one enstatite crystal on or near the contact. There is no obvious change in grain size of the gabbro at the contact and no contact metamorphic effects within the serpentinite. This latter feature shows that the gabbro did not intrude the serpentinite following serpentinization as serpentine is unstable above temperatures of the order of 500°C. (Bowen and Tuttle, 1949) and alters to forsterite and talc, whereas the gabbro would be at a temperature of the order of 800-1,000°C.

It is considered that the features of the contact and the dyke-like character of the gabbros are consistent with the intrusion of gabbro into the ultrabasic rock (enstatolite ?) and later serpentization of the ultrabasic rock. Probably as part of the same process the gabbro was altered to a garnet, chlorite, serpentine rock containing some residual pyroxene. The small crystal of enstatite on the contact, partly within the gabbro and partly within the serpentinite, is probably relict from the enstatolite and preserved from serpentinization by its partial inclusion within the gabbro.

The hornblende gabbro outcropping near 694E-277N is a leucocratic rock consisting of varying proportions of deep-brown hornblende and altered feldspar. In some specimens the hornblendes are aligned, possibly by flowage but more probably by shearing during crystallization. The hornblende shows slight alteration to chlorite but the feldspar has generally altered to saussurite with ghosts of zoned and cleaved feldspar crystals. Albite is present as rims to some feldspar grains and is probably secondary.

Specimens 8,156, 8,159 (6,915E-2,700N) occur in the western gabbro belt but are more basic types. In thin section the rocks are medium-grained and contain about 75% of pyroxene with augite dominant and lesser hypersthene. About 25% of the rock consists of fine-grained indeterminate material which may be secondary after feldspar. These rocks occur within 10 yards of the contact with Cambrian sediments and are separated therefrom by antigorite serpentinite (Specimen 8,178).

Within the ultrabasic complex are a number of bodies of very coarse-grained (1-5 cms.) pegmatitic gabbros. A small body (Specimen 8,195) occurs at 699E-271N but the main outcrops are a series of small bodies trending approximately north-south in the south-eastern corner of the complex. No exposures of the contacts with the enclosing ultrabasics were observed. The rocks are extensively altered, many of them to rodingites, but primary constituents were evident in sections 8,195, 8,198, 8,197 (south-eastern corner). In section 8,195 relict clinopyroxene occurs and the optical and X-ray data identify it as a calcic variety, possibly diopside (Film IV, Appendix). A similar clinopyroxene occurs as cores in secondary uralitic amphibole in section 8,198. Section 8,197 differs from the two preceding examples in that it contains 60-70% of deep red-brown primary hornblende in crystals up to 5 cm. long. There is no evidence of primary clinopyroxene and the hornblende shows only slight alteration to chlorite thus contrasting quite sharply with the alteration of the clinopyroxene in Specimen 8,198. The interstitial feldspar has been completely altered to fine-grained secondary calcium silicates.

From the examination of the limited number of specimens collected it appears that the pegmatitic gabbro suite includes rocks containing primary brown hornblende and altered feldspar which seem to differ only in grain size from the hornblende gabbro near 694E-277N. However, the pegmatitic gabbro suite also includes rocks with primary clinopyroxene and these show a similar degree of alteration to the pyroxene gabbros and rodingites of the western marginal belt. In many of the strongly altered pegmatitic gabbros it is not possible to say whether pyroxene or hornblende was the primary mineral but in view of the relatively slight degree of alteration of the hornblende gabbro from 694E-277N and of the pegmatitic hornblende gabbro from the south-eastern corner of the complex it is possible that the hornblende gabbros are a later feature. They may have intruded along similar channels to the earlier pyroxene gabbros, but at a later time, so that they were not subjected to the same strong alteration that produced the rodingites.

(c) *Alteration Processes in the Pegmatitic Gabbros.*—In the extensively altered gabbros, particularly from the south-eastern area, the breakdown of the feldspar appears to have been the first alteration process. In section 8,198 (699E-271N) the feldspar altered to a fine-grained, turbid material ("saussurite"). In section 8,195 the feldspar has altered, apparently directly, to a fine-grained turbid mass of grossular. An X-ray powder photograph of this material confirms the identification as grossular and not hydrogrossular (Appendix).

The breakdown of feldspar to "saussurite" and grossular was accompanied by changes in the pyroxene and amphibole, although these seem to lag behind the changes in the feldspar. The diopsidic pyroxene has been altered to an amphibole (tremolite-actinolite) and this mineral in some cases (section 8,198) has been altered to a pale-brown fibrous mineral which may be a calcic chlorite of the clintonite group. This mineral is rimmed by pennine containing inclusions of clinozoisite or epidote. In section 8,195 the secondary amphibole and sometimes the primary pyroxene appear to have been altered directly to chlorite containing small grains of sphene and garnet.

The most advanced stage in the breakdown of the original pegmatitic gabbros is shown by section 8,193. This rock is a rodingite and consists of fine-grained white grossular containing small patches (10%) of pennine. There is almost no trace of the original igneous texture in this rock. In all these rocks, assuming that the original feldspar was a calcic plagioclase, then the soda content of this feldspar has been completely removed. It certainly cannot be observed in a mineralogical sense in the chlorite-grossular rocks but chemical data have not been obtained to confirm the extent of this change. In these rocks there appears to have been introduction of lime and perhaps of alumina and water and removal of soda and perhaps of magnesia and iron.

Sections 8,194, 8,199, and 8,196 are of rock types which probably result from some change in physical conditions on the end product (section 8,193) of the breakdown processes. Section 8,196 has some areas of chlorite and turbid garnet very similar to section 8,193, but also has veins and patches of chlorite and pink vesuvianite, the latter being commonly euhedral. The associated chlorite is well crystallized and quite distinct from the secondary pennine. Section 8,199 also shows development of vesuvianite in veins, as small crystals in chlorite and as clear grains surrounded by turbid, colourless garnet.

A further stage in the generation of new minerals is shown by section 8,194. The grossular has almost all altered to vesuvianite and clinozoisite and instead of areas of secondary chlorite there are euhedral and subhedral crystals of diopside, vesuvianite and (?) pennine in a ground mass of nearly isotropic serpentine.

In section 8,198 the areas of turbid "saussurite" often contain shadowy spherulites of prehnite. All gradations between vague suggestions of these forms in the "saussurite" and perfectly clear prehnite spherules may be seen in the section and it is inferred that this series represents arrested stages in the growth of prehnite from saussurite. Associated with the prehnite are small grains of clinozoisite—these are especially apparent at the centre of a vein of prehnite showing comb structure.

(d) *The Albitite Suite.*—Bodies of albitite and related rocks are common within the ultrabasic complex, especially around 695E-275N. The bodies are generally very small (1-10 yds. diameter) and seem to be dyke-like or sub-circular in form. The albitites are included amongst the rocks which B. L. Taylor (1955) mapped as aplites, but this group also included gabbroic rocks.

The albitites commonly show several types of alteration, but specimen 8,187 is only slightly affected. This rock is medium to eoarse grained (0.5-3 mm.) and composed of interlocking, anhcdral albite (Ab_{94} An_{6}) and orthoclase microperthite crystals. The identification of the latter is not certain, but untwinned grains with patchy extinction forming 10-15% of the rock may be microperthite. Sphene occurs as uncommon subhedral and euhedral crystals interstitial towards the albite. Finely-fibrous serpentine and tremolite-actinolite form 10% of the rock and are considered to be a replacement of the feldspar.

Sections 8,188a and 8,188b are similar to 8,187, but eontain only about 60% feldspar with 25% antigorite and 15% tremolite-actinolite. The feldspar is of two types, albite (Ab_{93} An_{7}) and an orthoelase microperthlte very rich in the albite molecule oceurring in similar proportions. The microperthite has a variable 2V* (72°-86°), gave a negative result for the stain test for potassium using hydrofluoric acid and sodium cobaltinitrite solution and shows very strong exsolution of albite in veinlets and orientated erystals. These factors indicate a very high ratio of albite to orthoclase in the original microperthite.

The finely-fibrous antigorite and tremolite-actinolite commonly embay the feldspars along curved boundaries, sometimes eompletely separating parts of optically continuous feldspars. There is no trace of any pre-existing mineral from which the tremolite-actinolite and antigorite eould have been derived. In some cases the ferromagnesian minerals enter the microperthite along the site of veinlets of albite and on the small scale the boundaries of the feldspar are invaded irregularly by tiny needles of antigorite and sometimes by tremolite-actinolite laths. These features of the mineral boundaries strongly suggest that the ferromagnesian minerals have replaced the feldspar and the rocks show arrested stages in the basification of an albitite with soda, potash and alumina being replaced by magnesia, lime and, perhaps, iron.

In the area near Frenehman's Quarry (694E-280N) albitite and an amphibole-bearing rock occur in intimate assoeiation so that in hand specimen it cannot be said which rock intrudes the other. Only one thin section (No. 8,190) was cut from these rocks but this shows a coarse-grained, very pure albitite (Ab_{95} An_{5}) in contact with a rock consisting of amphibole (almost colourless tremolite-actinolite) and varying proportions of large and small albite grains. Small amounts of quartz, calcite, zoisite and sphene are also present. The albite commonly shows strain shadows, bent cleavage and other evidence of strain.

The albitite patches are crossed by narrow, linear cracks, varying in width but eontaining small angular grains of albite in the narrower portions and increasing amounts of zoisite and calcite in the wider portions. The calcite and zoisite have crystallized in their present position within the veins, but the albite has not done so. This is apparent from the angular, "clastic" form of the albites as opposed to the crystalline intergrowths of zoisite and calcite. Several smaller veinlets in the albitite are probably prehnite but these do not eontain the albitlte fragments. The calcite-zoisite-albite veins have their origin in the amphibole rock. The contact of this rock with the albitite is a larger scale example of that described for the calcite-zoisite veins. The albitite is fragmented along irregular eracks, fragments detached and apparently absorbed into the amphibole rock; they decrease in number away from the contact and some fragments are embayed by tremolite-actinolite.

The amphibole shows no trace of the former presence of any pyroxene; it is clear and fresh, fibrous or platey and varies greatly in grain size. In the general area near Frenchman's Quarry are large veins of amphibole asbestos (tremolite-actinolite) and it is considered that this material and that in the thin section have been formed by hydrothermal alteration of the associated ultrabasic and basic roeks of the immediate vicinity.

The textural relationships of section 8,190 strongly suggest that the tremolite-actinolite rock was in a fluid state or contained a very high percentage of fluid material. The fluid tremolite-actinolite rock invaded and included the albitite as xenoliths and ultimately seems to have replaced it with the resultant complete loss of the albite molecule. If this replacement occurred, then it is practically identical to that previously described (Nos. 8,188a and 8,188b) except that in the former case there was no evidence that the ferromagnesian-rich material ever became fluid and capable of mechanically fragmentlng the albitite.

Specimens Nos. 8,189 and 8,191 were collected near 6,960E-2,715N, where there are a number of small bodles of albitite in serpentinite. In hand specimen, No. 8,189 appears to be a graphic intergrowth of quartz (40%) and feidspar (60%). The feldspar is partially sericitized albite (Ab_{95} An_{5}) and occurs in large (2-5 mm.) anhedral grains. The quartz is clear and fresh but has an extremely irregular habit rather like reerystallized mortar texture. The quartz occasionally shows euhedral outlines against the feldspar and also sometimes against or inside other quartz grains. There are small pale-green needles, probably chlorite or serpentine, within the quartz.

The quartz generally embays the feldspar, though often the boundaries are linear but rough. In these cases the linear boundaries are usually parallel to or perpendicular to feldspar eleavage or twinning. In some cases optically continuous feldspar grains are completely separated by irregularly crystallized quartz. The author considers that the quartz has been introduced into a normal, crystallized albitite and has replaced part of the albite, giving an irregular intergrowth similar to the intergrowth between albite and antigorite-amphibole previously described.

* Determined on the universal stage by Dr. E. Williams of the Geology Dept., University of Tasmania.

An additional feature favouring the introduction of silica is the presence of talc in the immediate vicinity. Talc is rare in the complex and in this area could be due to the reaction:—

SERPENTINE + SILICA → TALC

$$H_4Mg_3Si_2O_9 + 2SiO_2 \rightarrow H_2Mg_3Si_4O_{12} + H_2O$$

(Turner & Verhoogen, 1951, p. 495.)

If we accept the silicification of the albite then this will also explain the formation of talc in the neighbourhood.

Specimen 8,187 is a hard, blue-grey fine-grained rock possessing a pronounced lineation. In thin section it is found to consist of albite (Ab_{98} An_2) and quartz (about 30%) in a well-developed mylonitic texture. The albite shows dimensional orientation and the quartz a parallelism of stringers and lenses. The quartz is very fine-grained and irregular in crystal habit, whereas the albite has the appearance of fragmented grains. It is considered that this rock was originally a silicified albitite similar to specimen No. 8,189 but that later strong shearing stress has destroyed the original texture and established a mylonitic texture.

Although no actual contacts have been observed, the field occurrence and the lack of apparent thermal metamorphic effects within the albitites indicate that these are late intrusions, probably post-dating both the gabbros and the ultrabasics. The albitites are more widely distributed than the basic rocks but there is no obvious spatial relationship between the two rock types. There is, however, a striking chemical relationship since the albitite contains the components (albite, orthoclase) which should be present in normal gabbroic rocks (1.5-2% Na_2O) but which have apparently been removed from the altered gabbroic rocks of this area.

Pure albite cannot exist in molten form below 1,100°C. and the presence of small amounts of potash is not likely to lower this melting point appreciably. If the albite "magma" was originally at such a temperature, then metamorphic effects should be very evident at the contacts with the serpentinite. The author has observed no such effects and it is inferred that the bodies have resulted from deposition from a hydrothermal solution.

Joplin (1956) discussed the relationship and composition of a number of Australian albitites and soda-aplites and connected them genetically with potash granites. However, potash granites do not outcrop within at least a 10-mile radius of Anderson's Creek and, other than the albitites, there is a complete absence of granitic intrusives in the Beaconsfield area. Surface float of granodiorite aplite occurs at 7,045E-2,670N, but these are boulders derived from the basal Permian sediments and are not intrusive into the ultrabasic complex. The rock differs very distinctly from the albitites in thin section although it is similar in hand specimen. Zoned oligoclase (55%) varies from Ab_{85} An_{15} in the cores to Ab_{90} An_{10} at the crystal edges and occurs in a eutectic intergrowth with quartz (40%). Biotite, muscovite and sphene are minor accessories. The distinct differences in feldspar composition, presence of biotite and particularly the textural relationships of quartz and feldspar, strongly suggest that the Devonian granite and granodiorite intrusions of north-eastern Tasmania are in no way related to the albitite bodies within the ultrabasic complex.

(*e*) *Rocks of Uncertain Affinities*.—There are a number of rock types of unknown origin which occur near the western margin of the complex. Specimen 8,161 was collected near 692E-273N and probably is that which B. L. Taylor (1955) called "hornblende granite". Other than the fact that it occurs on or very near the contact with the Cambrian sediments, its exact relationship to the other rock types is unknown due to lack of outcrop and to its similarity in hand-specimen to some of the gabbroic rocks. The rock consists of green hornblende, albite and quartz with accessory biotite, chlorite, sphene, magnetite and limonite. The texture varies rapidly, one area consisting of fine-grained, oriented hornblende grains with albite and small amounts of quartz, whereas the greater part of the section consists of large hornblende crystals poikilitically including albite and quartz. There is about 40% of quartz in these areas and the quartz generally shows wavy extinction.

The rock is distinctly different from other members of the gabbroic suite in that it contains virtually unaltered albite, no trace of calcic plagioclase, abundant quartz and a green rather than brown hornblende. The rock is a metamorphic one and is probably derived from contact metamorphism of Cambrian sediments by the complex. It resembles some of the rocks of the Simmonds Hill Metamorphics.

Specimen 8,162 was collected at 695E-253N near an obscured contact between gabbroic rocks and the Settler's Metamorphosed Greywacke. The rock is very heterogeneous. One portion of the slide is rich in tremolite-actinolite with small amounts of biotite and areas of unidentified fine-grained material. Away from this area there is a gradual increase in the quantity of fine-grained quartz present until the rock finally consists of some 70% quartz with small intergranular amphibole (?) crystals and unidentified fine-grained material. Feldspar was not observed in this section.

(*f*) *Conclusion*.—The Anderson's Creek Ultrabasic Complex is composed largely of partially or completely serpentinized pyroxenite (enstatolite) with lesser peridotite and clinopyroxene-rich rocks. Medium-grained and pegmatitic gabbros occur within the complex and some of these are strongly altered to yield rodingites. Hornblende gabbros do not appear to be as strongly altered and are probably later than the pyroxene gabbros. Small bodies of albitite within the complex are of hydrothermal origin. It is possibly significant that the alteration of the gabbros to rodingites requires a removal of Na, K and possibly Al and Si and the addition of Ca and possibly Mg and Fe. The components removed are those present in the albitites and there is a similar chemical transfer in the albitites themselves, since some examples show replacement of feldspar (Na, K, Al, Si) by antigorite and tremolite-actinolite (Mg, Ca, Fe). It is possible that these effects are features of the one process—migration of hydrothermal fluids initially saturated with Mg, Ca, and Fe, but preferentially

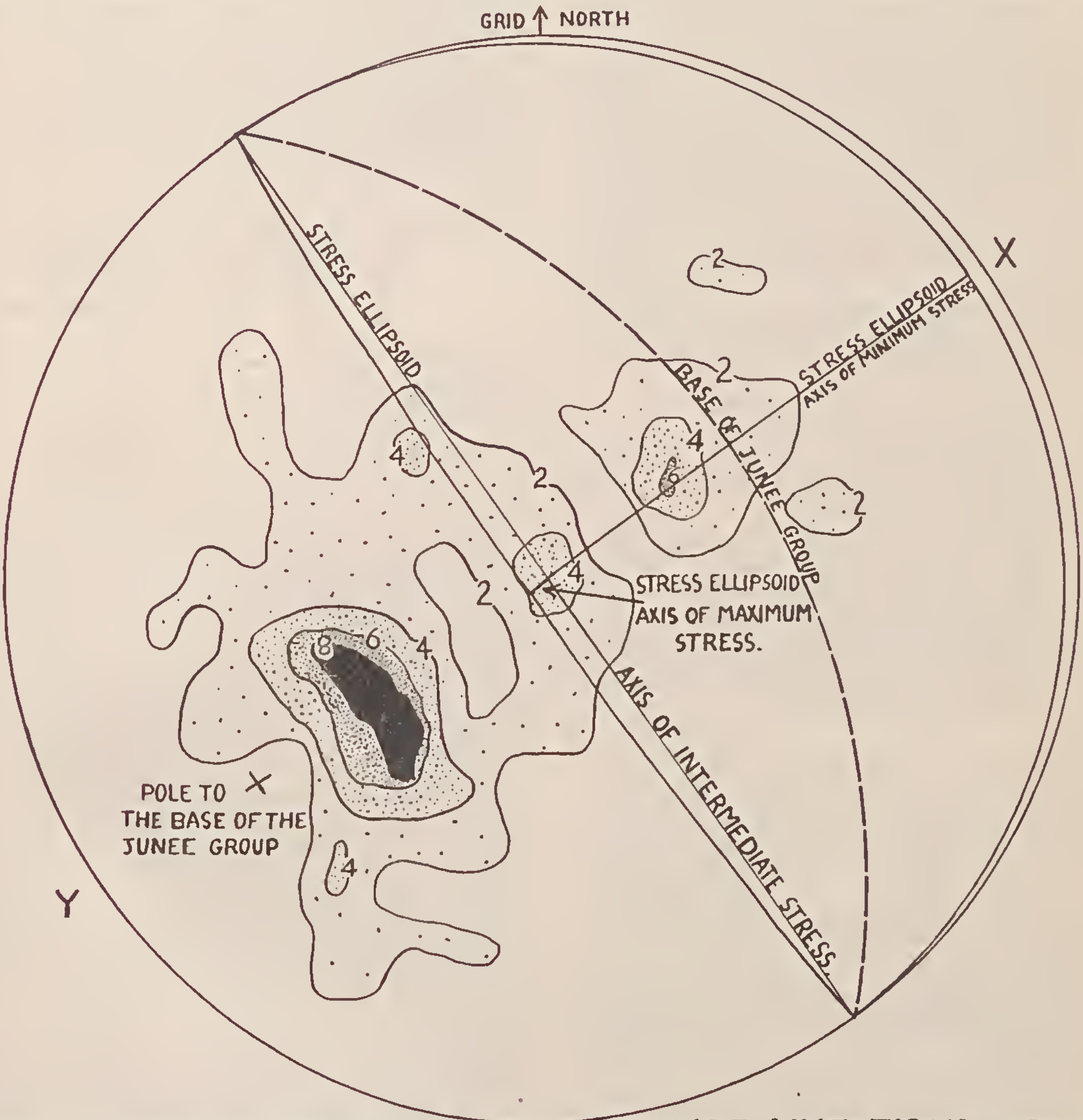

FIG. 5:—STEREOGRAM OF 87 SLICKENSIDE LINEATIONS FROM THE QUARRY AT 7065E 2595N ANDERSONS CREEK ULTRABASIC COMPLEX.

(CONTOUR INTERVAL 2, 4, 6 & 8% PLOTTED ON THE LOWER HALF OF A SCHMIDT EQUAL AREA NET) exchanging these for Na, K, Al, and Si when favourable rocks are encountered and locally depositing the latter components as small vein or dyke-like albitite bodies.

The complex intruded the Cambrian greywacke sequence in the Upper Cambrian and caused local contact metamorphism, particularly of a number of inclusions within the complex. Serpentinization of the complex is incomplete. Turner and Vehoogen (1951, pp. 251-2), in discussing the problem of serpentinization of ultrabasic intrusives arrived at the favoured hypothesis that the water required for serpentinization of an ultrabasic magma is derived from extraneous sources, generally from surrounding geosynclinal sediments undergoing compaction, metamorphism, &c., or else from intrusive bodies of granitic magma. With the lack of any evidence of the latter source in the Beaconsfield area and the presence of a considerable thickness of Cambrian sediments, serpentinization by waters derived from the sediments may be applicable in the Anderson's Creek Complex.

STRUCTURAL GEOLOGY

The Ultrabasic Complex.

The ultrabasic complex contains a variety of minor structures but these have not been mapped in much detail.

(*a*) *Slickensides and Shears.*—Shearing within the serpentinite has quite commonly produced linear zones of schistose serpentinite. A few of these zones are shown as "schistosity" on the accompanying map but no regional picture of their distribution and direction can be given. Along the eastern margin of the complex the schistosity has been mapped in a few localities:—

Locality.	Schistosity.	Contact (strike and dip of basal Cabbage Tree Conglomerate at the nearest point).
7,175E-2,115N	10°/75° W	355°/70° E
7,190E-2,370N	330°/60° SW	to the north-east 340°/80° E; to the south-east 20°/steep E
7,200E-2,425N	340°/80° W	340°/80° E
7,090E-2,640N	320°/80° NE	315°/55° NE
7,070E-2,650N	355°/70° E	315°/55° NE

Although the data is meagre it shows a parallelism or near parallelism in strike of the shear zones in the serpentinite and the base of the Junee Group.

Along the western margin of the ultrabasic complex, schistosity in the serpentinite is rarely well developed. However, near 697E-238N shear zones are very common and again tend to parallel the boundary of the complex which in this area is bordered by Precambrian rocks, the usual Cambrian sediments being absent. In the northern part of the complex near 693E-271N common shear zones strike into the contact of the complex and the Cambrian sediments, but it may be noted that they trend almost parallel to the strike of the basal Junee Group where this is exposed some ¾-mile E.S.E.

The slickenside surfaces of the serpentinite only become apparent where quarries have been opened. Eighty-seven slickenside striation directions from the Main Quarry at 7,065E-2,595N have been plotted on the lower half of a Schmidt net (fig. 5). The diagram shows one major (8%) and minor maximum (6%). The major maximum includes striae varying in plunge from 220° to 250° E of N and in dip from 55° to 62°. The minor maximum includes striae plunging 50° E of N at 62° to 68°. The base of the Junee Group, which outcrops ¼-mile away, strikes at 325° E of N and dips at 55° NE at its nearest point. As can be seen from fig. 5, the pole to the base of the Junee Group and the two maxima in the striations all lie on the same vertical great circle.

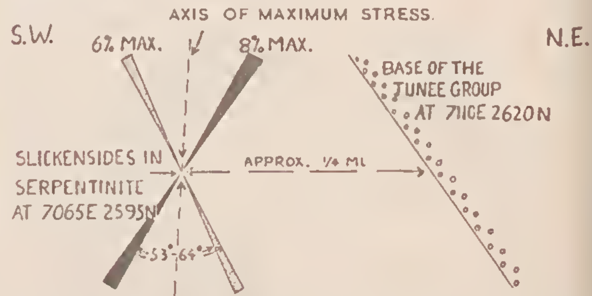

FIG 5A:—DIAGRAMMATIC SECTION IN THE PLANE X–Y OF FIG. 5

The author considers that these relationships are not coincidental and that there is a genetic connection between the disposition of the shears and slickenslides of the serpentinite and the base of the Junee Group.

(*b*) *Banding.*—Outcrops of the serpentinite commonly show a well-developed banding made apparrent by differing susceptibility to weathering of the bands. The bands differ irregularly in thickness and commonly continue for distances over 10 yards. When a fresh surface is exposed the bands are generally not visible or else are seen as faint differences in colour or texture of the serpentinite. The bands are generally straight or gently curving, but a number of examples of folded bands were seen. In one example the two bands consist of oriented pyroxenite and gabbro respectively, and in this case the banding may be due to multiple intrusion. No detailed study of the directions of banding was made but the few examples mapped appear to be rather random.

(*c*) *Oriented Pyroxenites.*—In five sceperate areas around 705E-263N partially serpentinized pyroxenites show a distinct lineation due to the alignment of ortho-pyroxene crystals with their cleavages lying parallel or sub-parallel. The examples mapped, all in a 10-chain square, show a variation in strike from east-west to north-south and have dips of 0°, 20°, 30°, 40° and 50°. No structural significance of their directions is apparent and it is unlikely that they are tectonic lineations but are due to flowage of the original magma. This would occur if the pyroxenite "magma" was actually a crystal aggregate or a crystal mush of pyroxene crystals. One contact of pyroxenite and altered gabbro showed alignment of the pyroxene crystals parallel to the contact, possibly indicating that the pyroxenite was the later intrusion of the two.

THE TYENNAN OROGENY.

The Junee Group has been shown to lie unconformably on the Cambrian ultrabasic complex in the western part of the area but probably disconformably on Cambrian sediments in the central and eastern parts of the area. The movements occurring during the Cambrian Period which resulted in the emplacement of the ultrabasic complex are correlated with the Tyennan Orogeny which brought about the cessation of Cambrian sedimentation elsewhere in Tasmania. Other than the emplacement of the ultrabasic complex and uplift of the Precambrian Asbestos Range Block to provide source material for the Cabbage Tree Conglomerate, the Tyennan Orogeny has had no other apparent effects in the area. The folding shown in fig. 3 in the Cambrian sediments near the complex is completely hypothetical.

THE TABBERABBERAN OROGENY.

The major folding of the area occurred in post-Ordovician and pre-Permian times and is considered to be due to the Devonian Tabberabberan Orogeny—the major Palaeozoic Orogeny in Tasmania. Fig. 3 shows the possible distribution of facies of the Junee Group and the relationships of the underlying Cambrian rocks before the effects of the Tabberabberan Orogeny. The thickness of beds formerly overlying the Junee Group is, of course, completely unknown. The two features of greatest importance structurally in this reconstruction are considered to be the thickness (3,000 feet) of Cabbage Tree Conglomerate developed in the central-south portion of the area and the presence of the ultrabasic complex between the Precambrian massif to the west and the column of Junee Group sediments, particularly the Cabbage Tree Conglomerate, to the east.

At the onset of the Tabberabberan Orogeny the area was compressed in an E.N.E. to W.S.W. direction. The axis of maximum compression of the regional stress ellipsoid is placed in this direction simply because this is perpendicular to the axes of the folds developed. Similarly, the axis of intermediate stress was directed N.N.W. to S.S.E. and the axis of minimum stress was vertical. Under this stress field folds of the Junee Group developed. The thick mass of Cabbage Tree Conglomerate on the southern edge of the area probably acted as a minor stable block, forming in itself an asymmetrical anticline facing west but causing the structures to the east and west to wrap around it slightly. The major N.N.W. faults parallel the fold trends and these are considered to have developed from the earliest stages of folding as steep reverse faults, perhaps actually the sheared-out steep limb of an asymmetrical west-facing anticline. This type of folding and faulting is typical of the Owen Conglomerate in other areas of Tasmania.

There is very little minor folding, but smaller folds do occur near the Moonlight Mine (738E-258N) and again near 765E-235N. Axial plane cleavage is well developed in the Cambrian Ilfracombe Slate and Dally's Siltstone and in the Leonardsburgh Siltstone.

Transcurrent faulting also developed during the Tabberabberan Orogeny and is localised in the central and west-central parts of the area. The major faults occur near 721E-239N and in a group at the north end of Cabbage Tree Hill. They are dextral transcurrent faults and have horizontal displacements of 1,000 feet or less. There may also be a major Devonian fault near 730E-277N striking almost east-west but concealed under more recent deposits. It is possible that the main Tertiary fault near Leonardsburgh has followed this previous fault line. If the fault exists then the drag of the Cabbage Tree Conglomerate at 730E-275N may indicate that it is a sinistral transcurrent fault. These transcurrent faults are consistent with the orientation of the regional stress ellipsoid suggested above. They are inclined at less than 45° to the axis of maximum compression and have the right sense of movement on them to correspond with the theoretical shear planes of the stress ellipsoid.

There remain two minor faults which do not fit well into the categories described above. The first of these is a faulted synclinal axis at 736E-261N with west side upthrown, and the second occurs between Blue Tier and Cabbage Tree Hill. This fault seems to be a pivotal fault about a point near 761E-233N. The northern wall of the fault has moved in a clockwise manner relative to the southern wall, so that the Junee Group on Cabbage Tree Hill generally dips more steeply to the north-east than that on Blue Tier.

The behaviour of the ultrabasic complex under the conditions of regional stress was rather different. It may be noted that the transcurrent faults do not apparently pass across the complex but seem to either originate in it or die in it. Carey (1953) discussed the behaviour of serpentinite under stress conditions and concluded (p. 83):—

> "In an environment of appreciable stress-difference maintained for a period longer than the rheidity for the serpentine, the serpentine would yield as a rheid. The associated rocks would probably behave as rheosolids yielding by both deformation and fractures".

Carey suggested that serpentinite, under shallow orogenic conditions, has a rheidity of some tens of thousands of years.

The parallelism of shears near the base of the Junee Group to the strike of the sediments and the striking relationships between the slickensides of the Main Quarry and the strike of the base of the Junee Group at its nearest point, argue that there is a genetic connection between the movement of the serpentinite and the attitude of the basal Junee Group. The slickensides are grooves formed on movement planes bounding blocks in which there is no obvious deformation—no apparent schistosity or other fabric. This observation argues that the serpentinite has behaved in the manner of a brittle material, i.e., stress has been applied at a sufficiently rapid rate to require release by fracture and, once formed, these fractures have become the locus for continued movement. If the serpentinite has behaved in the manner of a brittle material, at least as far as the fractures in this area go, then it should be possible to apply the stress theory to deduce the axes of stress .

Fig. 5 shows that there are two maxima in the orientation of the slickenside striations. If deformation has occurred according to the stress theory, then these two maxima should correspond to the movement directions on the theoretical shear planes and so we can deduce the position of the axis of maximum stress, since this bisects the acute angle between the maxima. The axis thus deduced plunges 235° at 87°. The axis of intermediate stress is horizontal and striking at 325° and the axis of minimum stress plunges 55° at 3°. These axes and the planes perpendicular to them are shown on fig. 5.

The intermediate axis of the local stress ellipsoid corresponds very well with the intermediate axis of the regional stress ellipsoid, but the maximum and minimum axes of the local stress ellipsoid are almost exactly at right angles to the equivalent axes of the regional ellipsoid. At first sight these features would seem imcompatible, but the author considers that under the geological conditions operating each is a necessary consequence of the other.

The regional stress field is considered to operate at some depth. The ultrabasic complex at 1-2 miles depth would be subject to the regional stress field and would be at an appreciably higher temperature than that part of the complex unconformably below the Junee Group, since the sediments in this area were probably less than 2,000 feet thick. Under these conditions the serpentinite at depth would have a lower rheidity than that beneath the Junee Group.

Accepting Carey's (1953) conclusion that the rheidity of the serpentinite would be lower than that of the enclosing sediments (Cambrian sediments and Cabbage Tree Conglomerate on the east and Precambrian quartzites on the west) then it must follow that the serpentinite would tend to intrude diapirically along a direction corresponding to the axis of minimum stress of the regional stress ellipsoid. This is valid at depth but the higher levels of the serpentinite have a higher rheidity and will not readily yield and move vertically. This serpentinite will rapidly become subject to a stress field due to the diapiric intrusion from below and this stress feld will be at right angles to the regional stress field. Provided the diapiric intrusion is rapid enough or the rheidity of the upper levels high enough, the serpentinite in these upper levels will behave as a brittle material and deform according to the stress theory applied to a stress ellipsoid with maximum and minimum stress axes at right angles to the equivalent axes of the regional ellipsoid.

It is considered that the demonstration at the Main Quarry that the local ellipsoid is at right angles to the regional ellipsoid can be accepted as showing that there has been diapric intrusion of the ultrabasic complex in the Tabberabberan Orogeny. The established relationships of the shears and slickensides to the strike of the basal Junee Group and not apparently to the Cambrian contacts shows that this diapiric intrusion occurred in the Tabberabberan and not the Cambrian Tynennan Orogeny. One important implication of the diapiric intrusion of the complex during the Tabberabberan Orogeny is that it is not necessary to "unwind" the folding of the Junee Group on the east of the complex to arrive at the pre-Devonian structure in the Cambrian and Precambrian rocks. If this were done in the normal way, then the complex would be seen as a sill-like body in a flatly-dipping Cambrian sequence.

Tertiary Faulting.

Tensional faulting occurred in the Beaconsfield area following the intrusion of the Jurassic dolerite and preceding the deposition of the Tertiary sediments. This faulting probably occurred, by analogy with the rest of Tasmania, during the early Teritary period.

The major faults trend in a north-west direction and thus generally follow the main Palaeozoic trends. In the south-west corner of the area a major fault downthrowing to the south-west brings Permian sediments into contact with the Cambrian rocks. There is no evidence of Permian float on Blue Peaked Hill and, if the base of the Permian is extrapolated from the eastern part of the area using a rather constant 10° dip, then a throw of about 2,000 feet is indicated on this fault. Using this latter figure the structure in the underlying Junee Group also becomes quite easy to reconstruct (pl. I). The fault runs north-west into the ultrabasic complex but cannot be traced further.

The inferred fault east of Leonardsburgh downthrows Permian Quamby Siltstone against undifferentiated lower Palaoezoic sediments. The throw may be 200-400 feet or greater. This fault is shown to swing to the north-east at the northern edge of the area, but this could not be proven and the fault could continue north-west. The other major north-west fault follows an irregular course along the eastern shore of Middle Arm. The throw on the fault cannot be estimated but is unlikely to be over 300-400 feet. The fault zone is exposed at several places along the shore line and varies from a 2-feet zone without exposure but lacking drag dip on either side, to a 10-feet zone in which large (10-feet) vertical blocks of sediment occur. There are lesser Tertiary faults trending nearly east-west; the most important of these occur near Leonardsburgh and again cannot be traced into the ultrabasic complex.

Carey (1947) has established the presence of a fault trough paralleling the Tamar Valley near Launceston and caused by early Tertiary faulting. These faults strike at 320°, which is nearly parallel to the main Tertiary faults of the Beaconsfield area. 30 miles to the north, and those west of the Tamar downthrow to the north-east. In the Beaconsfield area the only fault downthrowing towards the north-east between the Asbestos Range and the Tamar River is the rather less important fault east of Middle Arm. On the other hand, the major Tertiary fault in the area (in the south-west corner) has a throw of about 2,000 feet down to the south-west. The problem of the north-west extension of the Tamar trough must await the examination of the area between Beaconsfield and Launceston and also the area north-east of Beaconsfield.

SUMMARY AND CONCLUSIONS.

In the Beaconsfield area the Palaeozoic Era opened with Cambrian sedimentation of eugeosynclinal type upon a folded basement of Precambrian quartzites and phyllites. The total thickness of the sediments is unknown but towards the top there are over 2,000 feet of slates and greywacke sandstones. Sedimentation changed from greywacke type in the central part of the area to sub-greywacke type in the eastern part of the area. Vulcanism with extrusion of andesitic lava occurred during the Middle Cambrian in the eastern part of the area. The source from which the sediments were derived is unknown.

Sedimentation in the western part of the area was brought to a close in the Upper Cambrian Period by the intrusion of ultrabasic and basic rocks. This was a complex intrusion of ultrabasic (largely pyroxenite) and basic members with intermittent and localised serpentinization of the ultrabasic members, and saussuritization, garnetization and prehnitization of the basic members. Small bodies of albitite of hydrothermal origin were emplaced, possibly as a complementary process to the alteration of the gabbros and ultrabasics.

The intrusion of the ultrabasic complex and any concomitant folding apparently did not extend further east, as the Ilfracombe Slate shows no effects of two orogenies and disconformably or conformably underlies the Junee Group. Similarly, there is structural conformity between the Dally's Siltstone and the Junee Group. However, the age of the Dallys' Siltstone at a few hundred feet below the top of the formation is upper Middle or lower Upper Cambrian. The basal Cabbage Tree Conglomerate cannot be dated in this area, but the overlying Caroline Creek Sandstone is Lower Ordovician in age. It is possible that there was a period of the late Cambrian time in which there was no deposition. The rather sudden change from greywacke or sub-greywacke type sedimentation of the Cambrian System to the orthoquartzite suite of the Junee Group suggests a break in the sedimentation sequence due to orogenic action.

The Junee Group sedimentation probably continued throughout the Ordovician Period and may have extended through the Silurian and Lower Devonian Periods but evidence of this has been removed by subsequent erosion. The Junee Group shows rapid variation in thickness and apparently also in facies. The author's reconstruction of sedimentation conditions requires a prominent ridge or stable block in the position of the Asbestos Range with a thick lens of conglomerate and sandstones immediately to the east. These were followed vertically by and also change along strike into the Gordon Limestone which in turn passes into Mathinna-type sub-greywacke sediments. The limestone also undergoes a facies change to the west and north of the main (Flowery Gully) deposits and its place is taken by black siltstones and slates (Leonardsburgh Siltstone).

The period of sedimentation was brought to a close by the Middle Devonian Tabberabberan Orogeny. In the Beaconsfield area this caused shallow orogenic folding without igneous activity (with the exception of quartz and gold-quartz veining). The regional stress ellipsoid was oriented with the axis of maximum stress nearly horizontal and striking E.N.E.-W.S.W. and with the axis of minimum stress vertical. The effect of the regional stress field was to fold the Junee Group into a series of asymmetrical anticlines and steep thrust blocks with the thick mass of Cabbage Tree Conglomerate in the central south of the area acting as minor stable block. The stress field caused diapiric intrusion of the ultrabasic complex into the basal Junee Group which unconformably overlies it. Transcurrent faulting also occurred during the Tabberabberan Orogeny and seems to have been concomitant with the folding.

Following the Tabberabberan Orogeny the area was subject to peneplanation during the Carboniferous Period. This process was not complete by the beginning of the Permian sedimentation so that the basal Permian beds were deposited on a surface on which the more resistant rock types stood out as low ridges. The Permian sedimentation was dominantly marine and evidence of contemporaneous glacial activity in nearby regions is found in the general abundance of erratics. There are several probable disconformities in the sequence—at the top of the Liffey Sandstone, base of the Garcia Formation, base of the Palmer Sandstone and the base of the Blackwood Conglomerate—and on two horizons the conditions of sedimentation became terrestrial. These two horizons are the Liffey Sandstone in the middle part of the sequence and the Clog Tom Sandstone at the very top of the Permian sequence. During the Permian Period, abundant marine life in the area was restricted to several horizons in the middle part of the sequence (Darlington Limestone to Woodbridge Formation inclusive).

Little is known about the Triassic sequence of the area but quartzose and micaceous sandstones of freshwater origin were deposited. During the Jurassic Period discordant dolerite intrusions were emplaced and probably gave the post-Jurassic landscape considerable relief. The limonitic and haematitic surface-capping on parts of the ultrabasic complex and possibly on other rock types may have formed during the Cretaceous Period.

In the early Tertiary Period, tensional faulting with strong control by the Palaeozoic structural trends was followed by lacustrine sedimentation and then by minor extrusion of olivine basalt. After the basalt extrusion the Tertiary rocks formed a depositional surface at a height now 300 feet above sea level. It is probable that this surface extended over the whole of the area with the exception of a number of island-like ridges including Cabbage Tree Hill, Blue Tier, Blue Peaked Hill, the ridges of Cabbage Tree Conglomerate on the east side of the ultrabasic complex, several hills within the complex, and the Asbestos Range to the west.

At this stage there was a rise in sea level to about 300 feet above the present level. The above-mentioned high areas remained emergent as islands. The dominant rock type of these islands was Cabbage Tree Conglomerate and within this formation the components most resistent to abrasion, &c., were quartz veins and vein quartz pebbles. As a result, the washing to and fro in the shallow sea eliminated almost all eroded material except the vein quartz pebbles. These remained as the extensive, blanket-like vein quartz gravels.

The removal of the blanket-like quartz gravels and the underlying Tertiary lacustrine sediments from most of the southern and eastern parts of the area in ensuing periods of lower sea level has once more exposed the Palaeozoic formations.

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APPENDIX I.

X-Ray Diffraction Data.

The specimens were X-rayed, using a Unicam 3 cm. radius powder camera. Allowance was not made for film shrinkage in obtaining the following patterns:—

Film I.

Mesh texture serpentine from matrix of specimen 8,180:—

Relative Intensity.	d-Spacing.
10 S (sharp)	7.16
6 D (diffuse)	4.64
10 S	3.56
7 D	2.54
4 S	2.05
½ S	1.95
9 S	1.55
1 S	1.50

A comparison with Francis (1956) and Whittaker & Zussman (1956) shows that the material is chrysotile and not antigorite and, further, is probably dominantly orthochrysotile.

FRANCIS, G. H., 1956.—The Serpentinite Mass in Glen Urquhart, Inverness-shire, Scotland. *Am. J. Sc.*, Vol. 254.

WHITTAKER, E. J. W. AND ZUSSMAN. J., 1956.—The Characterization of Serpentine Minerals by X-ray Diffraction. *Min. Mag.* Vol., XXXI, No. 233, pp. 107-126.

Film II.

Pale green vein mineral from specimen 8,175:—

Relative Intensity.	d-Spacing.
10 D (diffuse)	10.82
8 S (sharp)	4.54
2 D	3.20
½ (spots) S	3.05
6 D } Edge of a	{ 2.62
5 D } broad band	} 2.48
½ S	2.30
1½ S	1.72
9 S	1.53
4 D	1.31

The mineral shows excellent agreement with garnierite (A variable hydrous nickel magnesium silicate).

Film III.

Dark-brown, isotropic and sub-translucent mineral from specimen 8,175:—

Relative Intensity.		d-Spacing.
2	S (sharp)	4.73
4	S	2.91
10	S	2.49
5	S	2.07
1	S	1.69
7	S	1.60
8	S	1.47
1	S	1.08

The mineral is certainly a chromium containing spinel and is probably chrome-picotite (Mg, Fe) O (Cr, Al)$_2$ O$_3$). However, the pattern differences between chrome-picotite, chromite (FeO (Cr, Al)$_2$ O$_3$) and nickel chromite (NiO Cr$_2$ O$_3$) are very slight. The optical properties (dark, translucent, brown colour) also favour chrome-picotite.

Film IV.

Primary pyroxene from pegmatitic gabbro (Specimen 8,195):—

Relative Intensity.		d-Spacing.
1	S (sharp)	6.91
1	D (diffuse)	4.68
3	S	3.53
3	S	3.22
10	S	3.00
9	S	2.52
2	S	2.31
5	D	2.13
3	D } Broad band	2.04
3	D }	2.01
5	S	1.84
6	S	1.75
7	S	1.62
7	S	1.43
3	S	1.33
5	S	1.28
4	S	1.08

The pattern has been compared with standard (card index) patterns for diopside and augite. The standard patterns show sufficient differences to be distinct from one another and the pattern above is in much better agreement with diopside than with aguite. However, it is not known how much slight variations in the chemical composition of augite control the X-ray pattern and data is as yet too meagre to be able to deduce the composition of a clinopyroxene from its X-ray diffraction pattern. All that can be said at present is that the X-ray diffraction pattern above agrees very well with that given for a diopsidic pyroxene of composition:—

53.88% SiO_2, 25.35% CaO, 16.95% MgO, 2.20% FeO, 1.28% Al_2O_3, 0.28% Fe_2O_3, 0.19% MnO, 0.04% TiO_2, and 0.00% Cr_2O_3.

Film V.

Secondary garnet from Specimen 8,195:—

Relative Intensity.		d-Spacing.
10	S (sharp)	7.02
5	S	4.62
5	S	3.50
80	S } Broad band	3.01
80	S }	2.94
100	S	2.62
10	S	2.40
10	S-D (diffuse)	2.30
20	S-D	2.15
60	S	1.91
50	S	1.70
70	S	1.63
80	S	1.57
20	S	1.47
35	S	1.32
50	S	1.29
5	S	1.26
2	S	1.19
50	S	1.11
30	S	1.08
20	S	1.05
30	S	0.96

The pattern above is very similar to the standard pattern for grossular. It is quite inconsistent with the pattern for hydrogrossular given by Scott (1951, p. 127). There is a consistent tendency for the lines of the above pattern to have a slightly lower d-spacing than those given for grossular. The patterns or almandine and pyrope have analagous lines to grossular but with distinctly lower d-spacings. It is probable that the slight consistent discrepancy between the above pattern and the standard grossular pattern is due to a larger amount of Mg or Fe replacing the Ca in the isomorphous garnet series

SCOTT, B., 1951.—Petrology of the Volcanic Rocks of South-East King Island, Tasmania. *Pap. Proc. Roy. Soc. Tas.*, Vol. 84, pp. 113-136.

Locality Index.

Locality	Lat. (S)	Long. (E)
Anderson's Creek	41° 10′	146° 47′
Asbestos Range	41° 06′	146° 40′
Barnes' Hill	41° 12′	146° 46′
Beaconsfield	41° 11′	146° 48′
Beauty Point	41° 09′	146° 48′
Blue Peaked Hill	41° 14′	146° 47′
Blue Tier	41° 14′	146° 50′
Blyth's Creek	41° 12′	146° 20′
Bowen's Jetty	41° 9′	146° 50′
Brandy Creek	41° 12′	146° 48′
Cabbage Tree Hill	41° 11′	146° 48′
Clog Tom Creek	41° 12′	146° 52′
Dally's Quarry	41° 12′	146° 49′
Flowery Gully	41° 15′	146° 50′
Ilfracombe	41° 8′	146° 48′
Langdon River	41° 59′	145° 31′
Launceston	41° 26′	147° 5′
Leonardsburg	41° 13′	146° 47′
Long Point	41° 8′	146° 51′
Middle Arm	41° 14′	146° 51′
Moonlight Mine	41° 12′	146° 47′
Palmer River	41° 47′	146° 59′
Settlers' Hills	41° 10′	146° 47′
Swift's Jetty	41° 9′	146° 51′
Tamar River }	41° 4′	147° 45′
Tamar Valley Estuary }		
Tasmania Gold Mine		146° 48′
West Arm		146° 48′